Chemical & Engineering NEWS

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Risks in selecting business's capital projects in the 1980's Page 37

Synthetic fibers' recovery flattens out

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Cover: Operator at American Hoechst plant at Spartanburg, S.C., monitors spooling of polyester filament

4 Letters
5 Editor's Page

Concentrates
9 Business
21 Government
25 Science/Technology

The Departments
58 People
60 Newscripts

News of the Week

- ***Protection of basic science is urged*** *by an NAS group in an unprecedented meeting called by the academy between leading scientists and government officials.* ***Page 6***
- ***Interim priority list of 115 sites*** *slated for hazardous waste cleanup has been released by EPA; high on the list is Florida with 16 sites.* ***Page 6***
- ***Rhône-Poulenc eyes its future*** *in light of promises by France's President François Mitterand to nationalize the country's chemical industry.* ***Page 7***
- ***Resignation of EPA's Anne Gorsuch is called for*** *by Rep. James Florio, chairman of the House Subcommittee on Commerce, Transportation & Tourism.* ***Page 8***
- ***Arthur M. Bueche dies at the age of 60:*** *adviser to U.S. presidents and statesman for science and technology, he spoke out on innovation and nuclear power.* ***Page 8***

Business

- ***U.S. synthetic fibers industry is hopeful*** *of quick recovery once the economy improves, despite current slowdown of shipments and relatively swollen inventories.* ***Page 10***

Government

- ***Environmental Protection Agency's*** *recent actions stir controversy; budget cuts and meetings with industry representatives called into question.* ***Page 22***

Science

- ***Some genes controlling nerve systems*** *have curious complexity, but with the help of powerful new techniques, their makeup is gradually being determined.* ***Page 26***
- ***Approval of prostaglandin use*** *to treat "blue babies" marks another step in the process of transforming these biochemical curiosities into useful drugs.* ***Page 27***

Education

- ***Salaries and promotions of women*** *with Ph.D.'s pursuing a career in academia still lag behind those of men with similar backgrounds, recent study finds.* ***Page 29***

Technology

- ***French process to make hydrazine*** *now is being used commercially, gives higher yields, and uses less energy than the conventional Raschig method.* ***Page 32***
- ***Method to reclaim nickel*** *from used batteries, developed at General Motors Research Labs, is boost toward commercial use of battery for electric cars.* ***Page 33***

Special Report

Evaluation and justification of new business projects *has become more hazardous as a result of sharp economic fluctuations, high inflation, and rapid shifts in currency exchange rates.* ***Page 37***

Business

Synthetic fibers recovery pauses

Shipments are slowing in stalled U.S. economy, but most producers believe that fibers will pick up quickly when economy improves

Despite some displeasing, hopefully temporary, current news, the U.S. synthetic fibers industry finally may be coming into its own from a more long-term view. The payoff could come fairly quickly once the U.S. economy picks up again.

Victims in the past of massive overcapacity and wildly fluctuating inventories, fiber producers are working hard to get both of these problems under control. And thus far, even under slowdown conditions, they are succeeding.

Plant capacity has been cut in all three of the large-volume noncellulosics—polyester, nylon, and acrylic. And inventories, though swollen relative to shipments, have not risen much in absolute figures.

"It's not a tremendous year, but it's a profitable year," sums up one industry expert. And it seems to be true.

In possibly the worst case, Monsanto had a $300,000 pretax loss in its textile division in the third quarter; for the nine months it had a pretax profit of $24.2 million. Even the small loss in the third quarter at Monsanto looks good against the $43.4 million it lost (pretax) in the same period of 1980. In the first nine months of 1980, the company's textile division racked up a loss of almost $115 million pretax.

At Akzona, chairman Claude Ramsey attributes much of the company's change from a 32-cent share after-tax loss in last year's third quarter to a 40 cents-per-share profit this year to Akzona's American Enka division, the company's fiber arm.

At Celanese, earnings for U.S. fiber operations in the third quarter increased 26% to 95 cents a share after tax from 70 cents a share in the same period last year. Most of this gain is in polyester, profits for which increased 164% to 29 cents a share. For the nine months, U.S. fibers earnings at Celanese increased 81%.

At press time, Du Pont, the largest fiber producer, had not reported its third-quarter results.

Producers have decided that it is better for them to cut capacity than to cut prices in the face of excess product. Over the past two years, official capacity of noncellulosics has been chopped about 2%. In some fibers, the capacity reduction has been as much as 5%. This at a time when capacity in most other parts of the chemical industry still is rising.

The capacity reduction has helped keep inventories in line, but producers have gone even further. They are no longer chary of temporarily closing plants or production lines when inventories of individual fiber types get out of line. The standard rule of thumb is that inventories should be equal to or less than one month's shipments. In general, producers have followed this rule in 1981. Only in July did inventories of noncellulosics get above the one-month shipments level, and even then it was by less than one day.

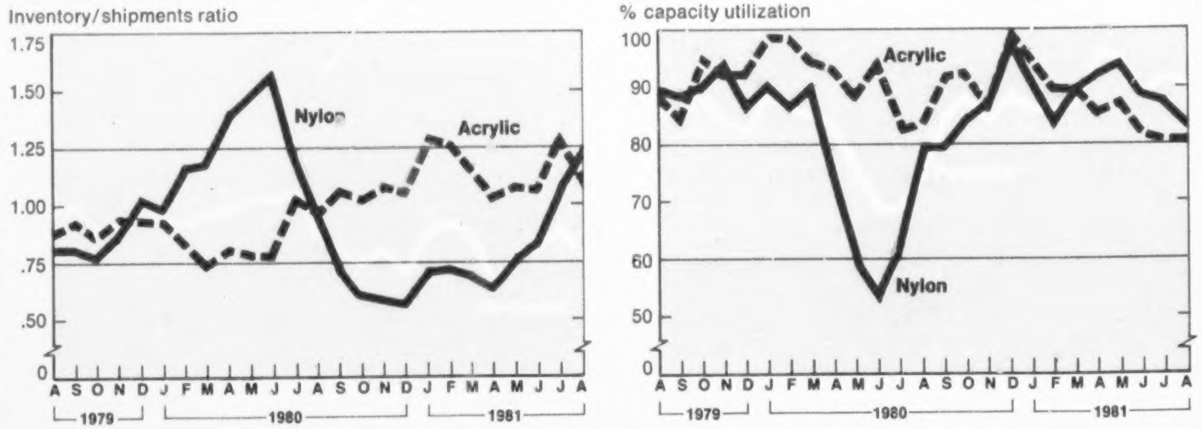
Further, producers say, inventories at downstream textile mills also are quite low. In fact, they see customers forcing inventories back on them because of high interest rates, which boost storage costs. With the low inventories at mills and fairly tight inventories at the producers' end, noncellulosic fibers makers see their product going short quickly if there is a turnaround in the economy.

In other words, the fibers business is hovering not far shy of prosperity for the first time in seven years. Although fiber firms still have one of the most quirky markets of any chemical product, their fundamentals, especially their high capacity use, look promising.

For details on the immediate outlook for polyester, nylon, and acrylic, see the following pages.

William Storck, New York

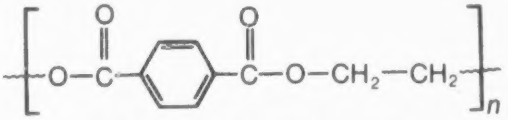
Polyester generally has outperformed nylon and acrylic in inventory control, capacity use



Sources: Textile Economics Bureau, industry estimates

Key Polymers

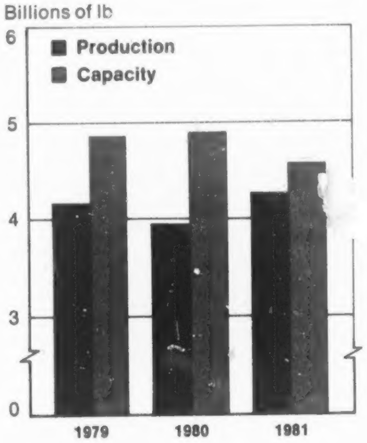
Polyester



Poly(ethylene terephthalate)

- ***Demand up slightly***
- ***Capacity down***
- ***Some discounting***

PRODUCTION/CAPACITY



HOW MADE

Reaction of ethylene glycol with dimethyl terephthalate or terephthalic acid to produce resin that is spun into fiber

MAJOR END USES

Apparel 62%, home furnishings 17%, tire cord 10%

FOREIGN TRADE

Exports—rising to more than 800 million lb in 1981, imports—will rise to about 20 million lb

PRICES

150-denier textured filament, $1.17 per lb; 150-denier feeder filament, 92 cents to $1.00 per lb; staple, 84 cents per lb

COMMERCIAL VALUE

About $3.85 billion for total production, 1981

In general, polyester fiber this year is in the best shape of all of the large-volume U.S. noncellulosic fibers. And not just by default.

Demand for polyester is up across the board from depressed 1980 levels. And producers are optimistic that they will be able to hold prices, if not at official listings, at least at profitable levels.

Polyester shipments for the first eight months were up 8.2% over the like period of 1980. This 1980 period had been down 5.6% from the year before. Thus, polyester shipments for the first eight months of 1981 are running 2.1% ahead of 1979, their last good year.

Specifically, it is polyester staple (the chopped form) that is holding the fiber above the 1979 levels. By contrast, industrial polyester shipments are off 17% from where they were in 1979, those of low-denier industrial are down 12%, and textile polyester shipments are down 1.5%. Thus total polyester filament shipments, while up 10.3% from the first eight months of 1980, are still off 5% from the same period in 1979.

Staple is a different story, however. Shipments of staple were virtually flat in the first eight months of 1980. Thus their 7% rise over that period this year translates into a like increase over the first eight months of 1979.

Producers say that polyester staple has been helped considerably this year by exports, especially to China. Exports, through the first half of 1981, were running about 20% ahead of the first half of last year.

Shipments of polyester fibers generally have been trailing downward for the past five months. They reached a year-to-date peak in April at 339 million lb and then demand began to decline, dropping 8% by July to 344.3 million lb. Demand picked up again in August to 369.4 million lb, but producers say that this was largely on the strength of the inceased exports.

Polyester fiber producers have been very careful about inventories, keeping them well below the industry level of one month's shipments. The result is that pricing in polyester, like that in other fibers, has held up fairly well this year. There is some discounting in textile filament and in staple, which is still listed at its first-of-the-year price of 84 cents per lb. Other types of polyester are fairly firm, however, having received a price increase in May. Polyester textile filament's price, in spite of being discounted 2 to 3 cents per lb, is still higher than its level of $1.07 per lb at the first of the year. The current list price is $1.17 per lb.

Producers say that they have finally learned their lesson and will shut down plant capacity rather than let overcapacity bring prices down to unprofitable levels. Thus, official capacity is about 6% below what it was a year ago.

For the next 12 months the wretched construction market will continue to have a dampening effect on polyester fortunes. However, producers are hoping for an upturn in demand for polyester apparel.

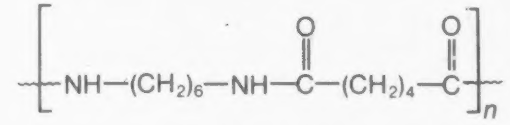
In apparel, producers speculate that there is a psychological factor at work: When consumers cannot afford big-ticket durable goods, they tend to buy more clothing. However, this theory has never really been tested. Moreover, another factor—a possible switch in the industry on the composition trend in polyester-cotton blends as cotton prices fall—perhaps could dampen a polyester upturn linked to apparel. The price of cotton has sunk like a stone in recent months. If cotton prices get low enough, some producers believe that there may be a change to more cotton in blends, reducing the amount of polyester staple used. Others believe that textile mills would find the change too expensive.

One thing that producers agree on is pricing. They think that unless the situation improves, polyester will not see its normal first-of-the-year price increase in 1982. That could be a problem. If flat 1980 prices of raw material ethylene glycol and dimethyl terephthalate start moving up again before polyester makers can pass them along in fiber price hikes, the result would be tough financially. Profit margins, which are in some cases rather thin, could turn down very quickly.

In general, though, polyester producers think they can hold out financially through the first half of 1982 in the current general economic slowdown. Then they are hoping that the last half of the year will bring some upturn in U.S. demand so they won't have to depend so heavily on the uncertainties of exports.

Key Polymers

Nylon

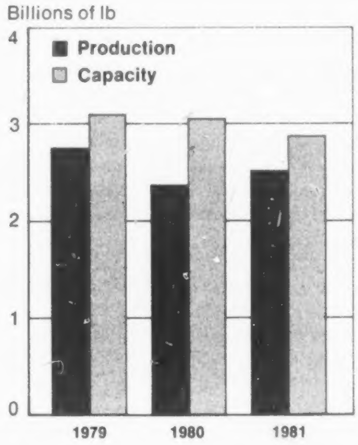


$$\left[-\mathrm{NH}-(\mathrm{CH_2})_6-\mathrm{NH}-\overset{\mathrm{O}}{\overset{\|}{\mathrm{C}}}-(\mathrm{CH_2})_4-\overset{\mathrm{O}}{\overset{\|}{\mathrm{C}}}-\right]_n$$

Nylon 66

- ***Demand down***
- ***Capacity off***
- ***Prices discounted***

PRODUCTION/CAPACITY



HOW MADE

Nylon 66—reaction of adipic acid and hexamethylene diamine to form hexamethylene diammonium adipate, which is then polymerized; nylon 6—polymerization of caprolactam by water; both types are then spun

MAJOR END USES

Home furnishings 59%, apparel 20%, tire cord 11%

FOREIGN TRADE

Exports—rising to more than 210 million lb in 1981, imports—will increase to about 30 million lb

PRICES

2500-denier bulk continuous filament, $1.45 per lb; carpet staple, $1.20

COMMERCIAL VALUE

About $3 billion for total production, 1981

No two ways about it—nylon is in trouble, in a year that promised better when it began. Now the worst off of any major U.S. fiber, nylon has once again fallen victim to its peculiar market lineup. For, although the fiber is popular for its apparel uses, most of it goes into housing-related outlets, especially carpets. Since this is where 60% of nylon winds up, the comatose construction industry has driven down the nylon business about as badly at the moment as in last year's recession.

Last year, nylon production fell about 13% from 1979 and shipments were off even more at 17%. Nylon staple suffered worst with a 31% decrease in production. Most of nylon staple goes into carpets. Nylon carpet filament in 1980 was off from 1979 levels.

On the surface, 1981 looks better. Total nylon shipments from January through August moved up slightly for an 8.5% increase over the first eight months of 1980. However, this is still more than 10% below the same period in more prosperous 1979.

More serious, demand for carpet nylon has been trailing off since April. Shipments of carpet filament hit 73.4 million lb that month but then declined 29% to 52.1 million lb in August. The same situation has occurred in nylon staple. August shipments of 52.8 million lb were 34% below April's.

September continued the decline. Carpet filament in September was off about 8% from August; staple was down another 5%. This augurs poorly for nylon, since September is normally pickup time from seasonally lower production in July and August.

So the end of nylon's troubles may not be in sight yet. The construction industry still is in the doldrums. Until it turns around, carpet nylon will suffer, having to rely largely on the replacement market for carpet and other uses.

The demand trough is reflected in pricing. The list price for workhorse 2500-denier bulk continuous filament used for carpets is $1.45 per lb, compared to about $1.25 per lb at this time last year. However, producers say discounts are so large in this filament that it is hard to know just what the current price is.

In response to poor demand for carpet nylon, producers have cut back on plant capacity. Production capacity of 907 million lb annually in May of this year was officially about 5% below its November 1979 level. But producers say that there have been further unofficial, temporary curtailments that have helped keep inventories and prices in better shape than they would be otherwise. Before these curtailments, according to industry experts, the situation got so bad that the discounted price of bulk continuous filament was below that of feedstock caprolactam.

Like polyester, nylon is getting a little relief in profit margins from flat feedstock costs. The price of caprolactam is generally about the level it was the first of the year, whereas the price of nylon is up somewhat.

Because of shutdowns in nylon capacity, capacity utilization is well ahead of 1980, although it is currently slipping. In 1980, capacity utilization averaged about 78% of the nameplate maximum for the year. This year, the average likely will move up about nine percentage points to about 87% of the total.

However, like the other noncellulosics, nylon's capacity utilization rate seems to have hit a peak in the spring. Capacity utilization was about 93% in the peak shipments month of April and 95% in the peak production month of May. It has since slipped to about 84% in August and probably will be somewhat lower in September after a slight nylon production drop that month.

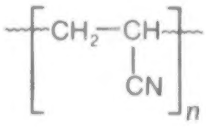
Among specific nylon grades, staple is probably the worst case. Capacity use for staple in September probably will be 75% or below. Producers believe that further capacity cutbacks may be called for to shore up the staple price, now a discounted $1.20 per lb.

For the near future, producers look for some further market erosion over the next few months. They are hoping for a pickup in the second quarter of 1982 as the general economy gets back on track.

Thus, though many producers expect a pickup next year, they believe that it could take until late in the year before production and shipments get back to 1979 levels.

So chalk up about a one-year gap in the nylon recovery that looked so hopeful at the beginning of 1981. The construction market holds the key.

Acrylic

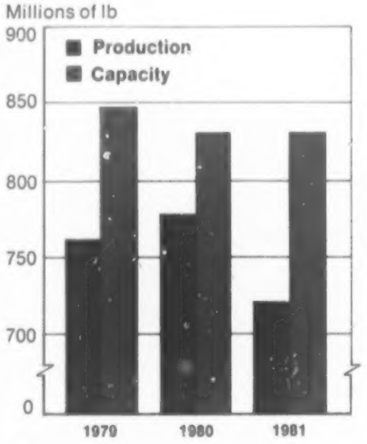


$$\left[-CH_2-\underset{\displaystyle CN}{\underset{|}{CH}}-\right]_n$$

Polyacrylonitrile

- ***Demand off***
- ***Capacity stable***
- ***Prices firm***

PRODUCTION/CAPACITY



HOW MADE

Polymerization of acrylonitrile, which is made by a catalytic reaction of propylene and ammonia

MAJOR END USES

Apparel 70%, home furnishings 30%

FOREIGN TRADE

Exports—rising to about 200 million lb in 1981, imports—falling to about 13 million lb

PRICES

3-denier staple for apparel, 98 cents to $1.10 per lb

COMMERCIAL VALUE

More than $720 million for total production, 1981

Acrylic fiber faces a painful profits pinch unless conditions improve quickly, which is unlikely. Alone among major fibers holding up through the 1980 recession, acrylic has joined the pack in 1981 with a general drop in business.

Acrylic's odd market behavior these two years is tied to the fact that consumer tastes in sweaters and apparel dominate acrylic's use pattern. Last year these clothing items were "in"; this year, apparently not so much.

Through the first eight months of this year, U.S. shipments of acrylic fiber dropped 7.8% to 484.3 million lb from the same period in 1980. The eight-month shipment figures for this year also are about 6% behind the first eight months of 1979. So like nylon, acrylic has a long way to go on its road to recovery.

Such recovery for acrylic may not be easy, tied as it is to apparel. One producer says that it's difficult, if not impossible, to predict exactly what is going to happen. "You just don't know how the fashions are going to change," he says. "What we need is a cold winter," he adds, referring to the large acrylic market in sweaters and outerwear, which use its wool-like properties.

Fortunately, exports of acrylic fiber are more than making up the ground lost last year. In 1980, exports fell about 16% to 75 million lb from 1979. This year, however, things are looking better. Exports through the first six months have risen 16% to more than 100 million lb from first-half 1980. Producers expect to finish the year with exports showing a good increase from last year—perhaps to just above 200 million lb. Although this still will be below 1979, it will go a long way to help prop up production in the face of falling U.S. demand.

Imports, a far smaller influence, are going the way of U.S. demand. Flat in 1979 and 1980, imports will drop this year. For the first six months, they were down 12% to about 9 million lb. Producers expect imports to continue falling for the rest of the year, finishing about 25% under the 18 million lb racked up in 1980.

U.S. nameplate production capacity for acrylic fiber is expected to remain at about 830 million lb. This is down from 848 million lb in 1979. Producers say that there should be no additions for some time; if anything, there may be a further cut. If this cut does not come in U.S. capacity—and it likely will not—it may come in Canada, which is a big exporter of acrylic fiber to the U.S.

With the cut in acrylic capacity in 1980, capacity utilization moved up about 4 percentage points that year in spite of an output increase of just 2.4%. This year, however, capacity use is declining. After starting out in January at about 96%, it quickly fell into the 80's. By August, capacity utilization was down to 81% with little prospect for its improvement in September. It now looks as if acrylic fiber will finish the year with plants running at an average of about 86% for all of 1981. In 1980, capacity utilization averaged about 94%.

The falling plant operating rate has not had much effect on list prices, producers say, although it may delay further price increases.

Prices for 3-denier staple for apparel run from 98 cents per lb to about $1.10 per lb. This is a much broader range than normal, indicating that there may be some price weakness. Last year at this time, there was just a 2-cent variation from 88 cents to 90 cents per lb.

The pattern of price increases this year also indicates some weakness in the market. Instead of increasing prices of all acrylic fibers at the same time, producers have been selective, raising prices of different types of fibers at different times.

In spite of this, however, producers say that pricing is fairly firm. It had better be, if they hope to maintain their profit margins. Acrylic fibers are the one noncellulosic where feedstock costs are rising. Precursor acrylonitrile prices are edging up, and upstream propylene pricing is "strong." Propylene is in somewhat short supply because of shutdowns in coproduct ethylene.

For the coming year, producers hope for a reversal of the current downturn, with shipments getting back up to 1980 levels by the third or fourth quarter.

Producers are, however, worried about profit margins for next year as feedstock costs continue to climb. If companies can start increasing prices in some orderly manner, things likely will work out. If prices can't move, acrylic fiber may resume its reputation as the weak sister of the noncellulosics.

Ph.D. women's careers in academia lag men's

Preferential promotion of men greatest in chemistry

	Ratio of men to women[a] 1960–69	1940–59
Chemistry	2.4	1.6
Biological sciences	2.1	1.7
Psychology	1.9	1.5
Physics	1.6	1.0
Mathematics	1.4	1.1
Social sciences	1.3	1.3
Other humanities	1.3	1.4
Languages and literature	1.2	1.4
All fields	1.5	1.4

[a] Ratio of male full professors to female full professors in 1979 by year of Ph.D. degree.

Though women with doctorates are more likely than their male colleagues to work at universities, the university is not a very equitable place for them.

If women earned their Ph.D.'s more than 20 years ago, their chances of now being full professors are only 73% of those of men with the same experience. If they earned their degree five to 10 years ago, their chances of having tenure are only 67% of those for comparable men. And their salaries, on average, will be 5 to 18% lower than those of men with the same degree and experience.

These are some of the findings of the National Research Council's latest examination of the differences between the careers of men and women in academia. Their report, "Career Outcomes in a Matched Sample of Men and Women Ph.D.'s," was prepared by the council's Committee on the Education and Employment of Women in Science and Engineering.

Studies that find women scientists are paid less and spend a larger part of their careers in lower level academic positions than their male colleagues have been made before. The American Chemical Society, for example, has much data that shows these trends for women chemists. In fact, the National Research Council itself conducted a study in 1979 that reached similar conclusions about women scientists in academia.

What is new about the present study, explains Lilli S. Hornig, who chaired the committee that prepared both the present study and the earlier one for NRC, is that it considers factors other than discrimination that might cause differences in the careers of men and women. Even taking these other factors into account, however, Hornig says the study "corroborates our earlier findings in virtually every detail." Among these factors are women's presumed larger investment of time and energy in marriage and parenting and their presumed restricted geographic mobility.

The present study tries to minimize the influence of these factors by matching one woman with two men to form a group of three people who all have the same characteristics. It then looks for patterns of promotion and salary among the people in these matched groups. There were 5164 of these groups in the study covering people who worked in various areas of science as well as languages and the humanities in 1979.

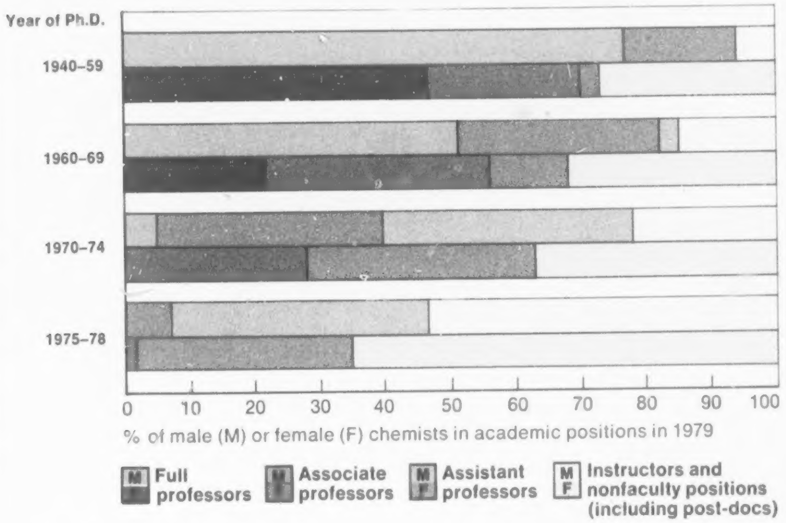
But even this careful matching does not make the career patterns of women and men at universities the same. "With male and female scientists and humanists closely matched by education, experience, type of employment, and even subfield in many cases, none of the differences we have noted previously in career progress disappear and few diminish," Hornig says. "Women remain less likely to be employed although seeking employment, their careers are apt not to develop as fully and they remain significantly less well paid."

Specifically, the study finds that of academically employed Ph.D.'s who were surveyed 20 or more years after obtaining their doctorates, 87% of the men but only 64% of the women were full professors. For chemistry Ph.D.'s the difference is even greater: 77% of the men but only 47% of the women were full professors.

Salaries, too, trail for women, and the salary difference between men and women is greatest in chemistry. For full professors of chemistry with more than 20 years experience, women earned $5500 (or 18%) less, on average, than men did.

At the other end of the scale, for academics who have earned their doctorates in chemistry since 1975, women earn $3300 (or 15%) less, on average, than men do. For these younger academics in all disciplines, the salary difference is $900 or 5%.

The report is available, for $10, from National Academy Press, 2101 Constitution Ave., N.W., Washington, D.C. 20418. □



Promotion at all levels comes later for women chemists

Source: National Research Council

Project Selection in the 1980's

Business fluctuations, inflation, shifting exchange rates create new hazards for profitability analysis

James B. Weaver
Wilmington, Delaware

The chemical industry has changed greatly since the 1960's, but the nature of the decisions facing its management has not. Management's most important decisions—and the most irreversible ones—still deal with the proper use of investment opportunities: expansions, new products, acquisitions. Such decisions remain a major responsibility of boards of directors.

Expanding assets is relatively easy, to be sure. The challenge lies in expanding profits along with assets.

As I said in C&EN 20 years ago: "A major objective of any manufacturing corporation is to provide the greatest possible long-term profit to its stockholders. This requires that its assets be used wisely and that they be increased in dollar value at the highest possible rate. . . . Nothing is more important than a series of successful capital investments in establishing a record as a profitable growth company."

For the past 20 years or so, analytical techniques have been available for evaluating the potential profitability of investment proposals, usually in terms of return on investment. This evaluation is derived from the net cash flow expected during the economic life forecast for the project. The future annual cash-flow schedule, in turn, is based on forecasts or projections of the key determinants of future income (such as sales volume, prices, capital requirements, and operating costs). Because funds are more valuable the sooner they are earned, future earnings are discounted, by compound-interest techniques, to a reduced current value for use in calculating a single, quantitative estimate of the project's overall profitability. The two most widely used techniques for doing this are very similar and usually lead to the same conclusion for any given set of future circumstances.

If there is a consensus accepting one set of cash-flow forecasts, this analysis permits management to judge whether a proposed project meets company standards for return on investment. The analysis also can be used to compare various projects available to the company at any one time or to weigh the effect of slightly different versions of a single project (variations in plant capacity or processes, for example) to choose the most profitable. And it can be used, too, to study the sensitivity of future earnings to changes in the key forecasts and thus to investigate risk.

The intent of such an analysis is not to replace management's judgment, but to simplify numerical interrelationships among revenues and costs in a complex project. Thus management has more time for considering other risks that do not lend themselves to quantification. As I also pointed out 20 years ago in C&EN, "By reducing a myriad of numbers to a few simple indicators, it permits management to focus attention on the many intangibles involved."

In the two decades since such methods for project analysis won wide acceptance, only minor improvements have been made. However, the advent of computers, with their massive ability to rapidly manipulate complex sets of numbers, has reduced the time needed to study many possible situations. When analysts were tied to mechanical calculators and slide rules, they often were a bottleneck limiting the number of variations that could be studied before a deadline. Now, many inputs can be stored in a computer, so the effect of a change in any forecast can be churned out in a few minutes or hours.

This suggests that company managers should be able to weigh the merits of competing investments more effectively and make better decisions. It hasn't worked out that way. Cycles of overproduction and shortages still occur in the chemical and many other industries. What went wrong?

Venture appraisal has been my career, and I've seen a wide variety of project proposals and justifications as I have moved from project analyst through several steps of management to a seat on a board of directors. The profitability techniques used to justify proposals are still valid and the best available, but they must be used in new ways now to contribute to better investment decisions.

Profitability analysis quantifies projects' potential return

There's no magic way to calculate potential profitability of an investment proposal—available techniques are simply mathematical models of an expected future situation. The first step is to decide just what elements will affect significantly the profitability of a proposed project. Detailed forecasts are needed for each of these elements, extending over the life of the project. One way of presenting such forecasts is by a cash-flow schedule. The example on the opposite page is typical and is derived from a real case for a new chemical plant producing two products. Note that almost all the key elements affecting profitability are reflected directly in such a schedule. The only exceptions are policy choices (depreciation life and minimum acceptable rate of return) and such background factors as forecasts of inflation rates or general business conditions.

Since the major parts of a new plant are likely to survive at least 10 years, that period often is chosen (as in the example) for the economic life of the plant. As with many other fairly arbitrary choices, however, each company should set a single standard "economic life" to use for new plants in all but exceptional cases, so that profitability studies will be comparable. A policy decision also must establish the depreciation method to be used in calculating cash flow. Although profits before or after taxes are important parts of the cash-flow schedule, only total cash flow, including depreciation, provides a full measure of the project's success.

The cash-flow schedule generated from any given set of forecasts summarizes all the essential information needed to assess the future of a project. That's important. The biggest costs in preparing a profitability analysis are in gathering all the data needed to develop such a schedule. Once data are available in the proper form, the final calculation is relatively simple, at least when compared with the procedures needed to estimate the data. Such calculation is further simplified by use of electronic computation, even on small hand-held calculators, to speed successive approximation procedures that are tedious when done by hand.

Cash-flow schedules are complex, however, so company officers and economic analysts have sought means to summarize the quantitative data into a single profitability measure. Decades ago, most companies used simple measures of profitability, such as the ratio of profits in a single early year to the original amount of investment (fixed plus working capital). But such ratios ignore much important information, such as trends during the life of the plant in prices, sales revenue, or various operating costs. By the early 1960's, two techniques, known as "present value" and "discounted cash flow rate of return," had been developed. They are still the best quantitative methods available for comparing various investments and selecting those best for company growth.

Both use compound interest techniques to discount cash flow (positive and negative) during the life of the project. This permits expression of the full sequence of cash flows as a single number representing the project's rate of return. (Obviously, the sooner projects return cash the better, so 10 years of individual annual cash flows just can't be added together.)

Each company has to choose a discount rate based on its time-value of money—either its cost of capital or something slightly higher to cover nonprofitable investments such as office buildings. This is its minimum acceptable rate of return. The present-value technique (also known as present worth or venture worth) discounts all the future cash flows at the chosen discount rate in order to reduce them to their net cumulative value at the start of the project. If this single cumulative present value is positive, the project earns more than the company's desired minimum rate of return. The present values of alternative projects competing at any one time for capital resources of a similar order of magnitude (whether mutually exclusive or not) then can be compared. This assumes the same discount rate is used and all the projects are discounted to the same point in time.

The discounted-cash-flow rate-of-return technique (also known as internal rate of return or interest rate of return)

Forecasts of key cash-flow elements dominate profitability analysis

	Likely accuracy of forecast
Major influence on profitability	
Installed cost of fixed investment	Good
Working capital	Fair
Sales volume forecast	Poor
Product price forecast	Poor
Raw materials	Poor
Other manufacturing and indirect costs	Fair to good
Inflation rates	Poor
Income tax rate	Fair
General business conditions	Fair to poor
Intermediate influence on profitability	
Economic life	Poor
Depreciation life	Good
Minor influence on profitability	
Construction period	Good
Salvage value	Poor

Recall for a moment the 1960's, when currently used project evaluation procedures first gained widespread use. In the U.S., business cycles seemed to be waning, so that recessions were less of an unpredictable hazard in company decisions. Stable economic growth looked like it would continue, both in the U.S. and most of the rest of the world.

In this environment, the newly accepted profitability techniques looked better and better. A consensus by management on the most likely set of forecasts (variously known as "best estimate," "proposed case," or "base case") usually was easy to obtain. As a result, many companies painstakingly established procedures to provide logical internal review of every major investment before it was recommended for approval by their board of directors. These procedures are themselves complex, and in larger companies the number of individuals involved in forming a consensus grew; staff personnel often were involved in the reviews as well as line management. Although risks and the sensitivity of forecasts to business conditions often were discussed, the one best estimate was emphasized. Multiple sets of forecasts always were considered distracting in a presentation to the board of directors. Many directors serve part time and need some seeks, by trial and error, to determine the highest interest rate that hypothetically could be paid on money borrowed for a project, based on the project's cash-flow schedule, and still let the project break even over its economic life. This breakeven discount rate then can be compared to the company's minimum acceptable rate of return to see if it meets that standard. It also can be compared to rates obtained from alternative or competing projects available at about the same time in order to select the most promising.

Note that both calculations represent expected profitability of a single cash-flow schedule (as in the example). Risk always exists that some of the forecasts used in developing the cash-flow schedule won't be correct, and such risk has increased in recent years. To grasp the possible impact of changes in one or more forecasts, other cash-flow schedules can be prepared, based on these changes, and their profitability calculated. Such calculations, called sensitivity studies, of various sets of forecasts represent the best way for management to arrive at a consensus in recommending a project for board approval. The studies also may be used to choose among projects, if resources are restricted, or to choose optimum characteristics (plant capacity or alternative processes, for example) for a project.

Several suggestions have been made in the past 20 years for improvements or modifications in present value or discounted rate of return techniques. These include the use of subjective probabilities (obtained by polling company officials) in making key forecasts, capital planning by use of linear programing, use of learning or experience curves (which tend to be swamped by inflation), and the altering of project-by-project profitability analysis by means of concepts derived qualitatively from long-range strategic planning. But there is little indication that any of these modifications are being used consistently in industry. We evaluated them at ICI Americas, but decided that none provided benefits worth the extra effort.

Project cash-flow schedule shows data that, when discounted, measure project's profitability

	Construction period		Start-up year						At capacity				
$ Thousands, current	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993[a]
SALES REVENUE	—	—	$ 501	$1191	$1597	$1924	$2088	$2338	$2527	$2760	$3002	$3297	—
Product 1	—	—	501	1031	1331	1517	1541	1722	1850	2008	2179	2385	—
Product 2	—	—	0	160	266	407	547	616	677	752	823	912	—
COSTS	45	108	741	1212	1481	1660	1739	1886	1995	2149	2238	2434	171
Purchased raw materials	—	—	300	706	938	1086	1150	1295	1392	1534	1602	1752	—
Maintenance, insurance, and taxes	—	—	59	78	85	92	99	105	111	115	125	132	—
Utilities and other operating costs	—	2	117	222	277	327	360	383	414	448	484	524	—
Depreciation (accelerated)	—	—	233	206	181	155	130	103	78	52	27	26	171
Commissioning and other project expense	15	77	5	—	—	—	—	—	—	—	—	—	—
Taxes during construction	30	29	24	—	—	—	—	—	—	—	—	—	—
TAXABLE INCOME	(45)	(108)	(240)	21	116	264	349	452	532	611	764	863	(171)
CASH FLOW													
Profit after tax, at 50%	(23)	(54)	(120)	10	58	132	174	226	266	306	382	432	(86)
Depreciation (add back)	—	—	233	206	181	155	130	103	78	52	27	26	171
Fixed assets	(607)	(536)	(35)	(18)	—	(20)	—	(23)	—	(26)	—	(29)	—
Investment tax credits	52	46	3	—	—	—	—	—	—	—	—	—	—
Net working capital change	(9)	(78)	(55)	(76)	(53)	(51)	(39)	(31)	(26)	(31)	(30)	(43)	522
NET CASH FLOW													
—Annual	($587)	($ 622)	$ 26	$ 122	$ 186	$ 216	$ 265	$ 275	$ 318	$ 301	$ 379	$ 386	$ 608
—Cumulative, year end	($587)	($1209)	($1183)	($1061)	($ 875)	($ 659)	($ 394)	($ 119)	$ 199	$ 500	$ 879	$1265	$1873

DISCOUNTED CASH FLOW RATE OF RETURN = 13%/year

PRESENT VALUE, ASSUMING MINIMUM ACCEPTABLE RATE OF RETURN OF 8%/YEAR = $472

Note: Numbers in parentheses are negative. [a] Working capital and 50% of undepreciated asset values recovered in year 1993. Salvage value is assumed nil.

training even to absorb all aspects of a project evaluation procedure.

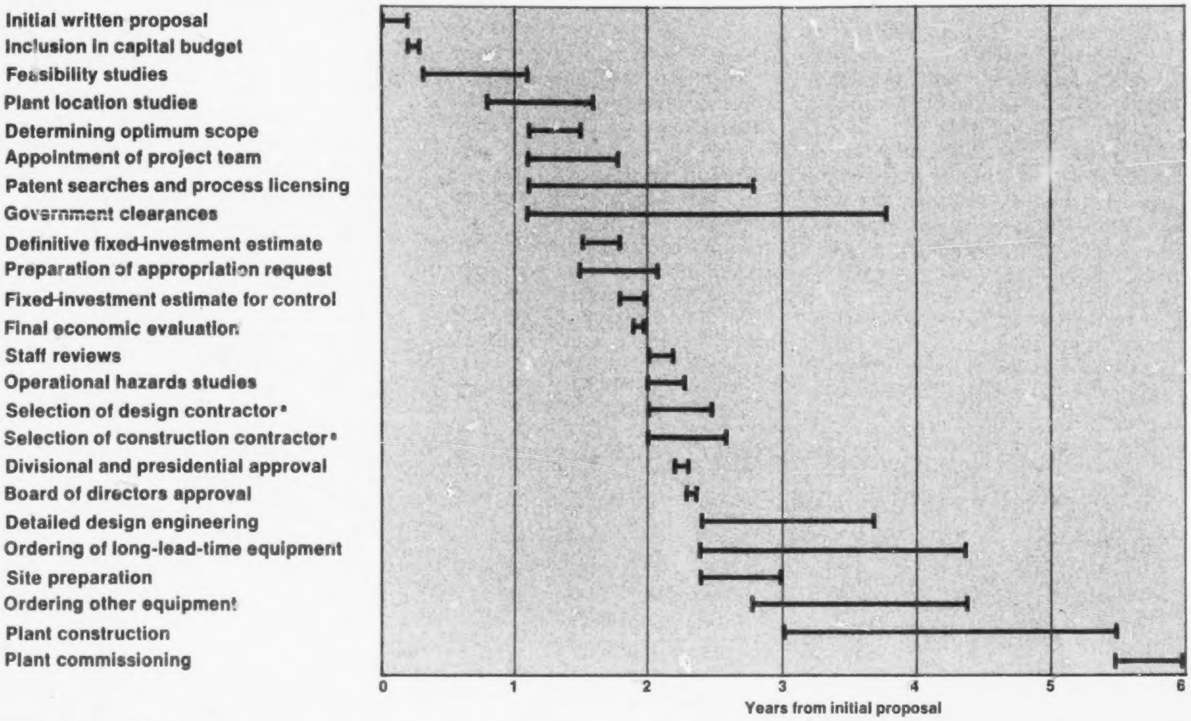
The business climate changed radically in the 1970's, and the changes are expected to continue through the 1980's. The usefulness of profitability techniques has been reduced as a result of increased uncertainty stemming from three economic developments:

- Re-emergence of sharp fluctuations in the business environment.
- Unpredictable inflation rates throughout the economy.
- Gyrations of floating currency exchange rates.

Each of these reduces the ability to foresee factors critical to forecasting investment profitability. The apparent continuing validity of the profitability techniques (and the acceptance of authorization procedures using them), however, may leave management with unwarranted confidence about its decisions.

A consensus of management on one set of forecasts is essential to profitability techniques used to evaluate an investment proposal when project authorization procedures are based on a single best-estimate case. But the best estimate is less certain now than it used to be and no longer may represent a broad consensus of management.

Many steps lie on the long road between project proposal and operating plant



a May be handled in-house.

Consensus on a best estimate, in fact, may be impossible. Profitability analysis techniques now must be used, therefore, in ways that don't seem compatible with established authorization procedures. Although computers make it feasible to study projects under many sets of conditions, providing real insight into a range of possible futures, current authorization procedures don't permit use of such insights. Decisions increasingly need to be based on insights from a range of forecasts, even though key personnel may differ about the likelihood of achievement of certain key forecasts—or of the assumed future business environment.

A real problem remains unsolved—how to bring such disagreement and uncertainty to the surface, either within the company or in presentations to the board. It is difficult to display all the complex ramifications and still recommend a major project clearly enough to win its approval.

One need, therefore, is improved procedures to present results from a diversity of forecasts. Authorization procedures should not be tied simply to a best estimate when real consensus is absent.

Other hazards also result from the large number of reasonable sets of forecasts now possible. The cost of gathering all the data needed for many sets of forecasts is higher, for one thing. And the computer printouts do not automatically show key assumptions. It's also tempting for project champions—at any level in the company—to propose one reasonable set of forecasts that they think will meet company standards—even if it really is no more likely than other sets of forecasts.

Commodity chemicals, sold to specification, should be pretty independent, of course, of the whims of fashion. If all commodity producers view market growth in the same way, and use similar profitability evaluations in making their investment decisions, those decisions generally should eliminate cyclic shortages and over expansion. Instead, even in periods of relatively stable market growth, some companies seem to base some decisions on goals other than short-term profitability. They may seek a higher market share, for example, even at some sacrifice of price and profitability, or they may desire entry into new markets.

Whatever the cause, commodity chemicals still regularly undergo surpluses and shortages, along with wide price fluctuations, and these never can be foreseen in making a typical profitability evaluation. The stimulating growth that everyone, including myself, expected for commodity chemicals and plastics a few years ago has fizzled. Polyvinyl chloride, thermosetting plastics, and chlorine are all well-publicized examples—and similar examples can be found in nonchemical industries.

From project proposal to operating plant

Every major investment project must go through many steps before it starts operation. Long experience shows that none of these steps can be skipped with impunity, although in total they usually consume three to five years, or even more for complete new plants. This means that forecasts of key project variables must be made long before the project is authorized—and even further before plant startup. If the business environment meanwhile changes drastically, the forecasts may become obsolete. Chemical equipment is so specialized that, past a certain point, incorrect decisions result in large sunk costs. That's why major plants or expansions are such important decisions for corporate directors.

In an acquisition, the size of the facilities being acquired usually is fixed. Therefore, there's less opportunity to choose among alternatives during the acquisition's evaluation. By contrast, feasibility studies of internal projects, whether plant expansions or completely new plants, may be numerous. Early economic evaluations may be very helpful during these studies in settling on the final scope of a project. After such preliminary studies, management proceeds to a definitive cost estimate of the chosen scope, which may be unlike the scope envisioned in preparing previous capital budgets.

On major projects, feasibility studies generally precede preparation of the approval documents, although there may be some overlap. Even with most inputs in hand, an authorization request may itself require weeks or months to prepare, particularly when changes in the business climate require new forecasts of key elements. Projects requiring board approval then must await the board's next meeting, another delay. This period can be used to obtain agreement of operating management, both line and staff, on all aspects of the proposal. But every delay makes all the forecasts used in the approval that much less accurate. The whole stage of the business cycle may change during the period in which the project is being studied, approved, and developed.

The biggest improvement in the use of profitability techniques in recent years is the availability of computer models, covering the full life of a project. Every conceivable piece of relevant information needed to develop a cash-flow schedule can be incorporated into such a model. For preliminary studies, when specific data for a project are not yet available, average or standardized data from similar, previous projects can be used to make a preliminary evaluation. As new or revised data become available or as new assumptions are suggested by anyone in the company, they too can be incorporated into the model in only minutes or, at most, hours.

The main advantages of such computer processing—speed and precision—more than offset its disadvantages. Today's speed of preparing evaluations of new project proposals could only be dreamt about 20 years ago. Computer procedures also can eliminate the possibility of arithmetic error, which avoids tedious checking and rechecking of numbers. However, the computer's precision is not matched by its accuracy; the human interface must be maintained to ensure that the data and assumptions fed into the computer are logical and internally consistent. This points to a disadvantage: Projected cash-flow schedules, the normal computer outputs, often are studied more carefully than critical input assumptions. Management, as well as analysts close to the model, should review current assumptions carefully as the time to make decisions approaches. Computer printouts can be designed to supply management with an intelligible listing of assumptions. Furthermore, the identity of individuals or reports that are the source of each key input for a forecast also should be available from the computer's memory, if possible.

Just before a decision is made, management personnel have a remarkable ability to dream up new and interesting changes among the elements used to project a cash-flow schedule. That's good. With most parts of the cash-flow schedule already in the computer, forecasts can be modified very quickly. Even modifications in key assumptions suggested by board members can be dealt with at the last minute.

Unfortunately, there is no simple way to summarize a mass of separate cash-flow schedules. Each involves differing assumptions and is a complete evaluation unto itself. And because the future is unpredictable, there is even less chance of a consensus on the forecasts. Any of a number of evaluations could turn out to be the most accurate and, therefore, the proper basis for a decision. But nobody has suggested a way for either authorization papers or the board itself to deal with a wide array of forecasts.

Another recent development that is heartening is the growth of specialized staffs formed specifically to make profitability evaluations. Because of their repeated exposure to all aspects of such analyses, specialists can bring key assumptions to the attention of decision makers, given the opportunity, and suggest improvements in projects. Experience in such work also provides useful training for future company management.

Such a staff must be protected and made independent of operating management, however, so that its evaluations are objective and not merely made to back a decision already favored by the operating management. And it must be treated by management, at all levels, as a partner in seeking the best decision. If the evaluation staff works within an operating group, it will be all too subject to the short-term pressures of day-to-day operations. Then it is far too easy for the staff, like everyone else in the group, to drift too soon into unanimity regarding a course of action, before all the business options have been thoroughly reviewed. Once such unanimity develops in an operating group, group management is likely to treat an analytically oriented, skeptical project evaluation staff more like adversaries then helpmates.

An unpredictably capricious environment

Improvements in profitability evaluations stemming from the growing use of computers have been swamped in recent years, in my opinion, by the three major churlish elements now affecting business: shorter and more severe business cycles; unsteady, uneven, and high rates of inflation; and wide fluctuations in monetary exchange rates. These developments explain why, despite business's acceptance of profitability techniques during the past 20 years, business decisions nevertheless have become more and more difficult and no more successful. The record of profitability for most chemical companies has continued to swing up and down, just as if their managements didn't know how to make major decisions correctly or weren't following any consistent procedures. The new elements in the business environment have not destroyed the relationships in the cash-flow schedules or the validity of accepted profitability techniques. But they do destroy confidence in forecasts, so that a consensus on a single set of forecasts for an investment project is harder to achieve.

In developing a 10- or 15-year cash-flow schedule, one has to assume a stable business environment, usually one growing steadily throughout the period under study. Sales volume and price assumptions also must be based on a stable environment. And the timing of cash flows is critical; because future earnings are discounted, the profitability of a project depends heavily on its achieving the sales volumes and profit margins forecast for it in its early years.

But the more pronounced business cycles of the 1970's are expected to continue. No suitable way has been found to handle such cycles and the resulting uncertainties regarding future income within current profitability techniques; the impact of a recession of any given magnitude can be shown, but the probability of its actually occurring is uncertain. Unless economists improve their ability to forecast the onset and depth of recessions, we are left with an unresolved problem.

The chemical industry went through two complete business cycles during the 1970's. Since the span from idea to approval to plant startup is about the same as from cycle to cycle, a plant rarely comes on stream in the same business environment as when it was approved.

Forecasting is not scientific; the business environment strongly affects the opinions of any forecaster. If a plant is proposed at a low point in the economy, price and sales volume forecasts will not be optimistic (or won't be accepted if they are) and the project probably won't be approved. However, if it is, the plant might start up when the economy is at its peak—and industry sales volumes and prices for the product may be well above what had been originally forecast.

Conversely, approval for projects is easier when the business cycle is at a peak; a good business climate leads to optimistic forecasts that also are more readily accepted by management. However, if the plant comes on stream at the bottom of the cycle, sales and prices may well be more disappointing than forecast.

Unsteady and uneven inflation

Inflation has been unsteady in recent years and uneven in its impact on individual products in any given year, even among relatively similar commodity chemicals.

From the beginning, the toughest forecasts to make in project evaluations were of sales volume and selling price. They have become even more difficult because of business cycles and inflation. The minor inflation usual in the 1960's could safely be ignored in project evaluations, but higher inflation rates in the 1970's demanded some sort of consideration. High inflation rates seem likely to continue in the 1980's, and no satisfactory method of forecasting prices of individual products yet surfaced.

Sharply varying inflation rates make cost and price forecasting difficult

December-to-December annual change, %	1980	1979	1978	1977	1976	1975
GNP deflator	9.8%	6.9%	8.6%	5.8%	4.7%	7.5%
Consumer price index	12.4	13.3	9.1	6.7	4.8	7.0
Chemicals and allied products	12.6	17.7	4.2	3.1	2.6	5.4
Industrial chemicals	14.5	27.6	1.7	[illegible]	4.9	8.4
Crude petroleum	26.6	50.7	8.4	9.0	0.7	17.8
Ethylene	21.5	41.7	2.0	5.6	12.3	26.3
Ethylene dichloride	13.4	25.2	−13.3	8.4	4.5	24.0
Chlorine	2.5	3.9	−0.1	−3.2	4.2	21.5
Sodium hydroxide	40.1	−8.3	−4.6	−2.5	−3.9	32.0
Sulfuric acid	25.4	6.9	−0.7	2.8	−2.0	11.5
Raw cane sugar	62.2	26.6	13.4	22.4	−27.6	−69.9
Lard	4.8	−3.4	5.5	21.8	18.4	−43.7
Inedible fats and oils	−3.1	−1.7	25.1	4.5	−1.0	−2.6
Domestic cathode copper	−15.5	47.1	17.5	−9.4	3.1	−13.8
Silver	−15.5	239.6	26.0	5.9	11.1	−4.9
Nickel—new scrap	−4.1	58.7	0.0	−8.0	4.1	−15.7

Source: Bureau of Labor Statistics, Bureau of Economic Analysis

If inflation were steady over time and affected all raw materials and other cost elements equally, published mathematical techniques show how to include inflation in profitability calculations. Even inflation rates that vary from one cost element to another can be handled, if the effect on each cost element is steady and foreseeable. But inflation not only differs among the various cost elements at any given time, it also cannot be predicted accurately. Who could have foreseen the sharp differences in inflation for various products that occurred since 1970?

Although forecasts of inflation are available from several sources, they differ and change often. Moreover, each is tied to a complex set of assumptions about business conditions, to which a user must also agree. Most forecasts indicate that inflation gradually will decline during the 1980's back to a level with which we can cope. Unfortunately, such optimism has not yet proven justified.

In the pleasant world of the 1960's, when inflation was slight, business cycles not in evidence, and costs and prices stable, current profit margins could be taken as a reliable measure of future expectations. A projected cash-flow schedule could be assembled from a stable set of cost elements, especially for familiar products and processes. (Even today, a cash-flow schedule based on current costs and prices, ignoring inflation, may be useful in preparing a profitability evaluation; it would indicate whether current profit margins are sufficient to support the investment project.)

But even assuming relatively constant inflation, it's not clear how today's profit margin must be increased to maintain in the future a profitability equivalent in purchasing power to the company with that it has today. Since the value of money is falling, a margin fixed in dollars per pound of product is also dropping in value. On the other hand, if the percentage margin of price over costs is maintained during a 10- or 15-year project life, the dollar margin will rise sharply with only a few years of high inflation. This will raise the calculated rate of return but may or may not increase the purchasing power of the profits.

Of course, minimum acceptable rates of return must be higher during a period of high inflation than what was acceptable previously, to compensate for the inflation. But just how much higher depends on an accurate forecast of all costs and prices, which now is impossible.

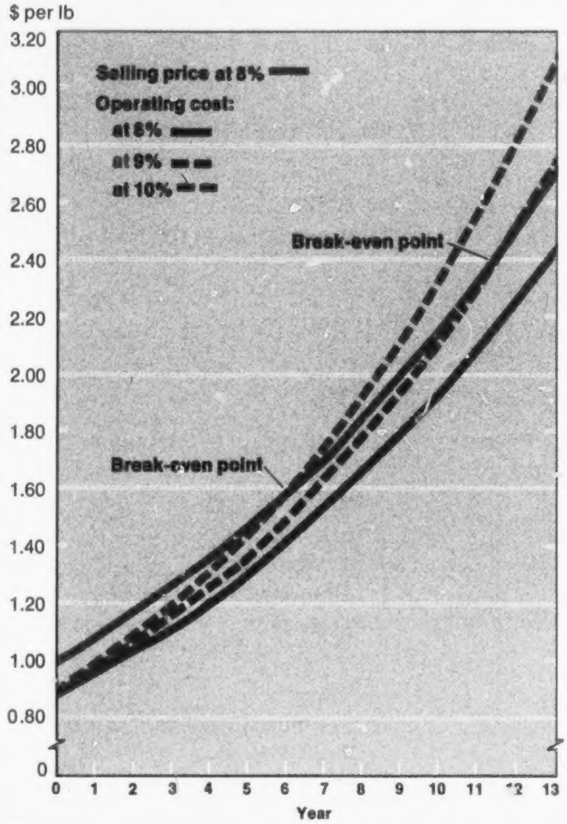
It's obvious, then, that economic evaluations cannot simply assume, as is often done, that all prices (raw materials and products) as well as project costs will rise at some average rate accepted by company management. Labor and other operating costs may rise at one rate while prices of raw materials and finished products increase at much higher or lower rates. And construction costs rose faster than average throughout the past 50 years (until very recently). Therefore, inflation rates must be forecast for each element in a project's cash-flow schedule to determine future costs and selling prices.

Gyrating exchange rates

Although the value of national currencies fluctuated before the current period of floating foreign exchange rates, recent variations have been wider and less predictable. Exchange rates are important in justifying investment projects whenever exports are significant or foreign plant locations are being considered.

One example from ICI Americas, the British-owned company I worked for, may illustrate the problem. Funds for capital projects were authorized by ICI in pounds

Inflation has a sharp impact on profitability



Even relatively small differences in inflation rates for costs and selling prices can affect profit margins drastically, as the chart above indicates. (The chart represents a somewhat simplified case, in that all operating costs are assumed to be completely variable rather than a mixture of fixed and variable items.) Precision in forecasting costs is impossible, however, making project analysis a very uncertain endeavor.

In the case charted, a product that costs 90 cents a lb to produce at present sells for $1.00 a lb for a 10% profit margin. The selling price is assumed to increase at a steady 8%-a-year rate. If the manufacturing costs also rise steadily 8% a year, the profit margin remains at 10%—although in 10 years profits per pound increase from 10 cents to about 22 cents a lb. If, however, costs increase 9% a year, only one percentage point faster than prices, profit margins erode steadily and disappear in 11 years. And if costs rise 10% a year, the break-even point for the product is reached in only six years.

sterling. When a major expansion in the U.S. encountered a significant overrun in dollars, explanations obviously were called for. But imagine our surprise to find that, because the dollar value of the pound was less than had been forecast at the time the project had been approved, the overrun in British currency was negligible. Recent decreases in value of the pound must now be creating other situations where a considerable cost overrun in dollars nevertheless may show an underrun in pounds.

Like many companies, ICI forecasts inflation and exchange rates each quarter for use throughout the company. Major projects took many months to assemble prior to final recommendations and more months to gain approval in both the U.S. and the U.K. Meanwhile, these quarterly corporate forecasts of inflation and exchange rates changed. Therefore, forecasts used in an authorization proposal were often obsolete before the project was submitted for final approval.

These variations usually did not change the final presentation of a proposal significantly. Volatile exchange rates, and changing forecasts thereof, nevertheless, can determine the results of certain studies. Theoretically, in a stable world economic environment, profitability techniques could be used to plan optimum worldwide strategy for locating new plants to make products such as commodity chemicals that are sold to identical specifications throughout the world. In one study at ICI, however, the relative value of a European plant, compared to a U.S. plant, depended on whether we worked in U.S. currency, using current exchange rate forecasts, or the European currency. A further study using the company's earlier quarterly exchange-rate forecasts showed that forecast profitability levels and comparisons of operations in the two regions depended heavily on when the forecast was done, simply because of changes in forecast of exchange rates.

Some analysts believe that differences in inflation rates between countries largely offset changes in the relative values of their currencies. While this seems logical, many other influences affect both, and our studies showed little correlation between the two.

I have been a major promoter and user of profitability techniques, and I still am. Such techniques still provide a useful means to analyze a potential cash-flow schedule. However, a more perverse and capricious business environment has made forecasting more difficult, so that each cash-flow schedule and profitability calculation is far less useful than was the case 20 years ago. The best estimate is much less likely to occur, so consensus on a set of forecasts is rare. Computer models permit display of an endless variety of results, to show sensitivities, but none has a high probability of being closest to the truth.

Proper use of profitability evaluations requires that each forecast be given less weight than before but that a variety of reasonable forecasts be made to show the wide range of possible future cash flows. Less emphasis should be placed on attaining a consensus or preparing a persuasive presentation around one best estimate; instead, ranges of key assumptions should be presented and their impact on future profitability discussed. This admittedly raises problems when corporate directors seek brevity and clarity in the proposals presented to them. But the alternative is worse: decisions made without the true risks of an investment having ever surfaced.

The biggest roadblock to accomplishing these changes, however, may be the very nature of the proposal authorization procedures used in large corporations. Like profitability techniques, these developed as part of scientific management, but they now are obsolete if they rely solely on a single best estimate. This is true even if the profitability techniques themselves are still valid. But authorization procedures are complex and hard to change. Boards of directors and operating management also are familiar with current techniques and formats and therefore usually loath to change.

As long as current authorization procedures are used, though, a greater hazard exists. Because a variety of cash-flow schedules can be turned out by a computer, it is tempting to choose a favorable one as the best estimate, whether it is more probable than others or represents a real consensus. Improved computer models and the speed of computer calculation lend an aura of confidence to the best estimate forecasts, whether it is justified or not.

In many ways, the variety of possible forecasts and evaluations puts the basis for making decisions back on the intuition of company management and directors. Faced with many forecasts of cash-flow schedules in mesmerizing detail, decision makers may feel they must again make seat-of-the-pants judgments, much like early entrepreneurs. Nevertheless, they are better informed with an array of cash-flow schedules than without; the schedules at least allow the best possible application of business intuition.

Maybe better techniques can be found, particularly for summarizing the variety of cash-flow schedules into a simple presentation. But until they are found, the whole array of cash-flow schedules is needed if the best-informed decision is to be reached. □

Selected readings

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James B. Weaver was vice president for venture and capital appraisal of ICI Americas before retiring last year and establishing his own venture consulting business. After earning a B.S. (1944) and M.S. (1947) in chemical engineering from Massachusetts Institute of Technology, Weaver held staff positions in the research departments of Godfrey L. Cabot Inc. and Olin Industries. He joined the economic evaluation staff of Atlas Powder (later Atlas Chemical Industries) in 1954. He was appointed vice president of ICI America in 1973, the year after Atlas had been acquired by Britain's Imperial Chemical Industries, and elected a director of ICI United States in 1974. Weaver has written numerous articles on cost engineering, economic evaluation, and profitability appraisal techniques (including one in C&EN, Sept. 25, 1961, page 94), and he is coauthor of a chapter on cost and profitability estimation in "Chemical Engineers Handbook," edited by Robert H. Perry and Cecil H. Chilton.

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- 10 grams 5% palladium on carbon powder, 50% water wet
- 10 grams 5% palladium on alumina powder
- 10 grams 5% platinum on carbon powder
- 10 grams 5% rhodium on carbon powder
- 10 grams 5% ruthenium on carbon powder

Kit #2 For Fixed-Bed Reactions
- 20 grams 0.5% palladium on 4-8 mesh granular carbon
- 50 grams 0.5% palladium on ⅛" alumina pellets
- 50 grams 0.5% platinum on ⅛" alumina pellets
- 50 grams 0.5% rhodium on ⅛" alumina pellets
- 50 grams 0.5% ruthenium on ⅛" alumina pellets

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Chemical & Engineering NEWS
November 9, 1981

Major solvents face no growth in 1982
A Key Chemicals Review Page 12

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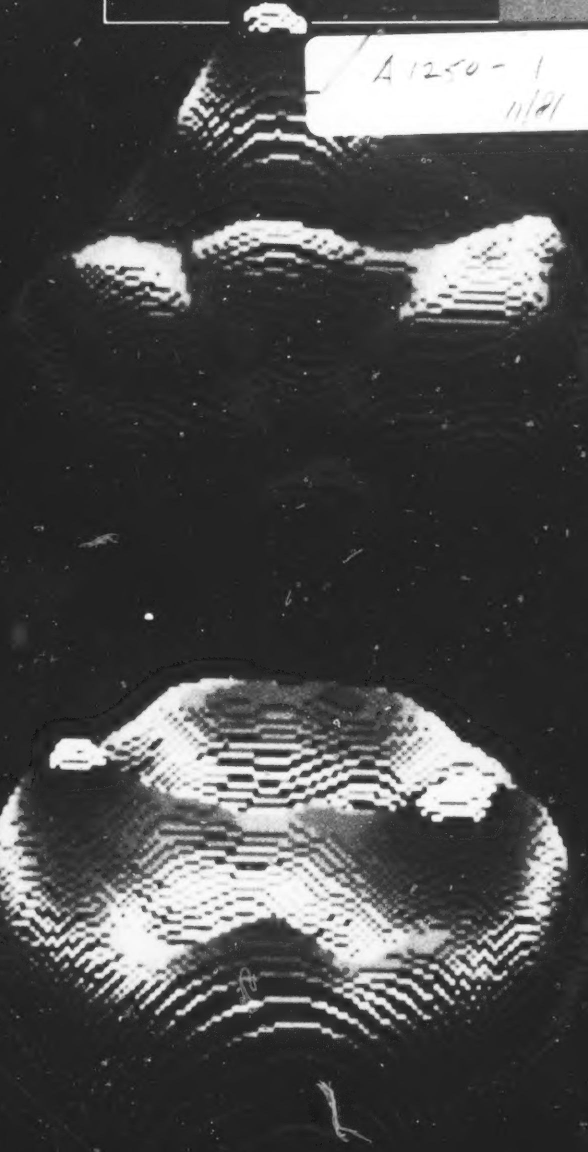

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Positron tomography

Advances in synthesizing radio-labeled compounds
Page 30

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Chemical & Engineering NEWS

Cover: Positron tomographic images of glucose metabolism in brain sections of a schizophrenic male (top) and a normal male (bottom). The schizophrenic's eyes are open, leading to high metabolic activity in the occipital cortex (back of image). Large blue-green area in the frontal cortex (front of image) signifies the depressed metabolism characteristic of schizophrenics. Photo courtesy of Brookhaven National Laboratory/New York University PETT project.

4 Letters
5 Editor's Page

Concentrates

11 Business
25 Government
29 Science/Technology

The Departments

55 People
56 Newscripts

News of the Week

- ***Amendments to the Freedom of Information Act*** *that would maintain the confidentiality of business and technical data proposed in two bills before Congress.* ***Page 6***
- ***Montedison suspends sales*** *of low-density polyethylene, citing unrealistically low selling prices.* ***Page 6***
- ***Chemical industry committee*** *for American National Metric Council sets 1984 as target date for shipping and billing industrial chemicals in metric units.* ***Page 7***
- ***Approval for marketing of new drugs*** *has accelerated during the past few weeks as FDA heeds the President's call to ease regulations that hamper industry.* ***Page 7***
- ***Alkali metal detector*** *for coal-derived synthetic fuels production prevents corrosion of gas turbines.* ***Page 7***
- ***Council for Chemical Research,*** *formed to strengthen industry/academia ties in chemistry, aims to increase industrial funding for academic research.* ***Page 8***

Business

- ***Major solvents show no sign of recovery;*** *another U.S. recession and increased imports result in a poor outlook.* ***Page 12***

International

- ***Brazil's alcohol fuels program*** *targets more ethanol for chemicals and pushes ahead with joint R&D efforts.* ***Page 17***
- ***Aromatics face a number of pitfalls*** *in the decade ahead; unstable markets and uncertain demand contribute to the rising mood of pessimism.* ***Page 18***
- ***U.S. chemical firms in Europe*** *seen as having potential for expansion from present levels because, in part, of their flexibility in investment decisions.* ***Page 20***

Government

- ***Budget authorizations,*** *including those that fund federal research and development, are still heading Congress' agenda even though fiscal 1982 has begun.* ***Page 26***
- ***Congressional critics*** *charge Energy Secretary is dismantling DOE, cite failure to prosecute oil companies for pricing violations, employee firings.* ***Page 28***

Science

- ***Radiochemicals are key components*** *of diagnostic technique—positron emission transaxial tomography—to detect biochemical abnormalities in living tissue.* ***Page 30***
- ***Molecular structure of toxin*** *produced by red-tide algae determined by multidisciplinary team of scientists.* ***Page 38***

Books

- ***"The Ecology of Tomorrow's World"*** *by John Elkington, British urban planner, stresses resource conservation as the means of solving environmental problems.* ***Page 40***

No recovery in sight for major solvents

Current economic downturn combines with rising imports to give acetone, ethanol, and methylene chloride a troubled outlook for 1982

As 1981 enters its surprise finale, another U.S. recession, producers of three important organic chemicals used largely as solvents—acetone, ethanol, and methylene chloride—will be closing their books on a no-recovery year. Unhappily, the books then will open on an equally unpromising 1982.

Solvents didn't have that much profits steam even before the last recession in 1980. They have less now and a pack of other troubles even without the current recession. Underlying market growth is spotty, and competition is beginning to hurt from alternative chemicals and foreign supplies.

The depressing result is that these three solvents probably will turn in a third straight, recession-level performance in 1982. Production volume will stay flat at a combined 4.0 billion lb, and total production value will remain stuck at $1.1 billion, the same as in 1980.

Actually, this value should be up more than 10% over the past year if producers are to recover their inflated costs. Admittedly, producers are finding ways to cut some production costs of most chemicals, and some raw materials price pressure has eased. But producers probably aren't cutting costs so much as inflation increases them.

The upshot for the next few years will be loss of new investment money for these solvents. Excess plant capacity is large for all of them, and all three have operated at less than 70% of nameplate capacity in 1981. This hurts income growth, since prices can't be increased and in fact are being widely discounted.

With low growth rates and, in the case of synthetic ethanol, competition from a brand new, nonpetroleum technology, several years will be needed even to reach existing capacity limits.

Ethanol is the most complicated and possibly gloomiest case of the three solvents. Some synthetic ethanol capacity might well be shut down later in the 1980's because of an upsurge in ethanol production from plants using grain-based, government-subsidized fermentation processes. Ethanol already has had a decade of plant shutdowns in the 1970's because of slipping demand.

The other two solvents also will have their peculiarities in coming years. Methylene chloride, one of the four chlorinated methanes, is made in the same plants producing the other three—methyl chloride, chloroform, and carbon tetrachloride. Changing the chlorine concentration permits wide changes in the product mix. Although no capacity seems likely to be shut down, the mix might shift radically in future years to more profitable products unless methylene chloride can recover its earlier growth promise.

Acetone's odd twist is its dependence on coproduct phenol production. In general, three quarters or more of acetone is produced via this route. When phenol demand falls off as it has this year, acetone production also must decline. Since the long-term outlook for phenol's dominant market in housing is getting less favorable, the longer-term outlook for phenol and, in turn, acetone production could be a holding pattern at best.

Still, acetone can't be driven into an artificial shortage even if phenol demand stays low. Considerable capacity for acetone exists in independent plants based on isopropyl alcohol. This capacity could take up any slack in acetone supply for some time. One possible difficulty in theory could be raw material propylene supply for isopropyl alcohol because of artificial market shortages caused by imbalances in multiproduct olefins plants.

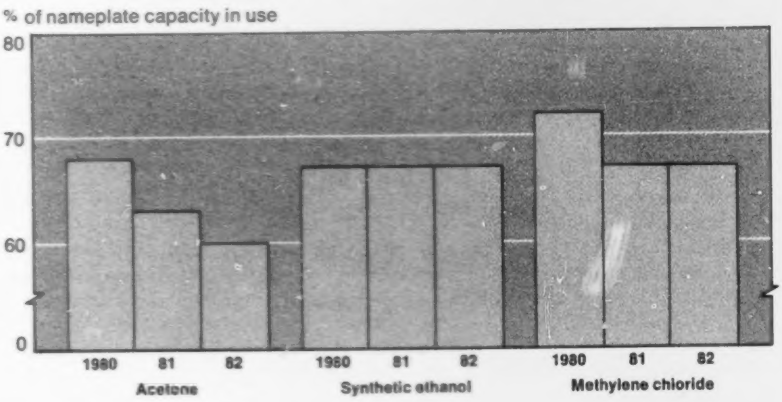
Longer term, the demand outlook for these solvents condemns them to slow growth, undoubtedly erratic as business cycles push these vulnerable products up and down. U.S. markets will have to absorb increased imports and declines in exports. The foreign trade flip-flop already has hit as costs of these products in the U.S. rise to meet or exceed worldwide averages.

Rising imports from regions with relatively less costly feedstocks also may have to be absorbed into U.S. markets. Such imports would tend to put downward pressure on U.S. prices, further hurting profitability and future investment. Imports, particularly ethanol made by fermentation processes, could lead to shutdown of U.S. capacity or at best conversion to other products.

For details on the immediate outlook for these solvents, see the following pages.

Bruce Greek, Houston

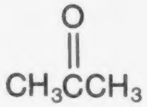
Plant use will stay very low for solvents in 1982



Sources: Industry, C&EN estimates

Key Chemicals

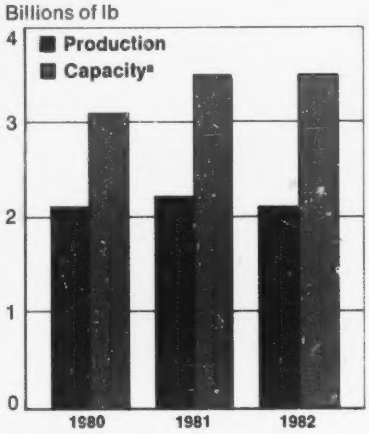
Acetone



$CH_3\overset{\overset{\displaystyle O}{\|}}{C}CH_3$

- ***Demand off***
- ***Some capacity idled***
- ***Prices discounted***

PRODUCTION/CAPACITY



a First quarter.

HOW MADE

Coproduction with phenol by oxidation of cumene; dehydrogenation of isopropyl alcohol

MAJOR DERIVATIVES (U.S.)

Methyl and other methacrylates 30%, methyl isobutyl ketone 10%

MAJOR END USES (U.S.)

Solvents, alone or as derivatives, 60%; fabricated plastics 30%

FOREIGN TRADE

Exports—declining to about 175 million lb in 1981, imports—negligible

PRICES

Below-list price 29 cents per lb

COMMERCIAL VALUE

$600 million for 1981 production

The U.S. acetone business will tilt downhill next year, swerved from recovery by a weak U.S. market and falling exports. It won't make much difference that demand also is down for acetone's coproduct, phenol, which controls acetone output. Spare acetone is always available from independent isopropyl alcohol-based plants.

In 1980, roughly 80% of 2.2 billion lb of acetone produced in the U.S. came as coproduct with phenol made from cumene. The remainder came from dehydrogenation of isopropyl alcohol, by far the older of the two processes used to make acetone.

With a renewed U.S. recession now apparently under way, hurting housing starts and commercial construction, demand for phenol in this important market will slide during the rest of 1981 and at least through some of 1982, probably until midyear. As a result, acetone production likely will drop to perhaps 2.1 billion lb in 1982. This will follow a slight upturn in 1981 production but will put acetone volume right back where it was in 1980.

Hence, three essentially flat production years will leave acetone swimming in extra plant capacity, even though capacity currently is overstated. Of the total 3.5 billion lb per year of nameplate capacity, about 250 million lb has been shut down for periods between two months and more than a year. This shutdown estimate could be low in view of the slow demand for phenol. Another 100 million lb of capacity might be down as well, bringing the shutdown figure to 10% of the total.

On a nameplate basis, 1981 production of acetone will result in an operating rate of only 60%, not very profitable. Owing to the confirmed or rumored capacity shutdowns, the operating rate at plants actually running more realistically will be about 70%.

Just over a third of total acetone capacity now is based on isopropyl alcohol. Yet only about 20% of production comes from this source. This share may be rising, however, because of depressed demand for phenol, which lowers the operating rate for cumene-based plants. Nevertheless, the fraction of acetone from isopropyl alcohol still won't reach the nominal one-third share of capacity during 1982.

Prospects for renewed growth in acetone demand in 1981 and 1982 are not good. The U.S. market will have to absorb a reduction in exports in 1981 of about 75 million lb. Although this decline in exports accounts for only 3.5% of production, it could more than equal demand growth this year. A further decline in exports during 1982 is expected by some industry sources, meaning that even more acetone would have to go into U.S. markets.

If the recession continues well into 1982, U.S. demand might not expand enough to absorb the export loss. The result will be lower production quite apart from the influence of lower demand for phenol. Because production of acetone from isopropyl alcohol is considered the "swing" source, this acetone flow will rise or fall to handle the net demand change.

The use pattern for acetone will change little over the next year or so. The larger uses in solvents and manufacture of methacrylates look flat for a year or so because of the recession. Changes in air pollution control regulations hurting other solvents might help acetone a bit eventually, but for now a more important influence is the state of the business cycle.

In methacrylates, growth has slowed from more than 10% a year during the 1970's to an estimated 3 to 5% annually later in the 1980's. These resin materials will continue to be the largest single use of acetone but no longer will be the rising star of the use pattern. The methacrylate markets other than methyl methacrylate are relatively small and all told may account for only 15% of the use of acetone in methacrylates.

Of all acetone uses, bisphenol A is expected to continue to have the best growth rate, possibly more than 6% annually for the 1980's. This product, formed by reaction of acetone and phenol, goes mainly into epoxy and polycarbonate resins. Other bisphenol A uses are small-volume specialty resins. Producers of bisphenol A also make the two raw materials, providing some higher-value captive use for both to help improve profitability.

On balance, for the rest of 1981 and well into 1982, acetone producers hope simply to hold their current production level and then await better times.

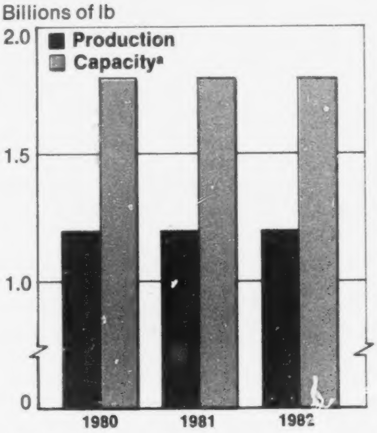
Key Chemicals

CH_3CH_2OH

Ethanol

- ***Demand flat***
- ***Capacity excessive***
- ***Prices soft***

PRODUCTION/CAPACITY



[a] Synthetic only as of first quarter.

HOW MADE

Synthetic—hydration of ethylene

MAJOR DERIVATIVES (U.S.)

Esters 10%, amines 5%, ethers 5%

MAJOR END USES (U.S.)

Solvents 55% (80% including derivatives), food 10%

FOREIGN TRADE

Exports—holding around 60 million lb; imports—rising, may reach 350 million lb, including fermentation ethanol used industrially

PRICES

List prices, between $1.90 and $2.10 per gal

COMMERCIAL VALUE

$350 million for 1981 production

If it's raining on the economic outlook for acetone, it's pouring on ethanol. In fact, it's hard to imagine what more could go wrong.

Most U.S. producers of synthetic ethanol based on petroleum expect three consecutive years from 1980 through 1982 of flat production at about 1.2 billion lb, or a bit more than 180 million gal, the standard industry measure.

It might take beyond 1983 for production to again exceed 1.4 billion lb or 210 million gal, the 1979 level.

This output plateau in synthetic ethanol follows a long-slumping decade after the peak of 2.3 billion lb, or 348 million gal, in 1969. This long-term decline has brought plant shutdowns, and current nameplate capacity of about 1.8 billion lb per year, or 270 million gal, is well below the former peak production level.

At the moment, about a third of this synthetic ethanol capacity isn't needed. None is expected to be shut down in 1982, but later shutdowns might dot the 1980's as in the 1970's.

If this weren't enough, synthetic ethanol producers must now contend with fallout from U.S. production and imports of fermentation-process ethanol based on grain. Government-subsidized and now lower-cost, fermentation ethanol slowly has eased its way into long-held markets of synthetic ethanol even though the market originally intended for the fermentation product was gasohol in the unrelated fuel business.

Plant capacity for fermentation ethanol continues to rise in many parts of the world. However, many targeted fuel markets are proving a disappointment. In some countries, subsidies are the spur to this construction. In others, the incentive is improved technical efficiency combined with very low-cost raw materials.

In the U.S., fermentation ethanol, either domestically produced or imported, is increasing its newfound share of "industrial" markets for petroleum-based ethanol. These markets are defined as those other than fuels (gasohol) and beverages. Many of these uses are in the lower-grade areas for solvents. These contrast with higher-quality outlets such as cosmetics, in which customers are very concerned about ethanol purity. Here, synthetic ethanol still generally gets the nod.

Ethanol's two-tier uses and sources easily can throw confusion into ethanol statistics, even official government production data. For example, most industry sources put 1980 synthetic ethanol production at 1.2 billion lb, roughly the same as the preliminary estimate of the government's International Trade Commission. However, the final ITC production number is higher by some 200 million lb. Industry analysts believe the new figure has errors that developed during ITC's efforts to get hard reports of all ethanol production and thereby eliminate estimates used in preliminary numbers.

Similarly, ethanol consumption data in industrial uses have become less clear because of a blurring of ethanol sources. In 1981, ethanol use in industrial markets, excluding fuels and beverages, is expected to total 200 million gal, possibly 205 million gal, or 1.3 billion to 1.35 billion lb. Of this, synthetic ethanol will supply about 170 million gal, or 1.1 billion lb. The rest of U.S. synthetic ethanol production, 10 million gal or so, will be exported. Imports, mainly fermentation ethanol, and domestically produced fermentation ethanol will supply the rest of U.S. demand, 30 million to 35 million gal.

Much incentive exists for such sale of fermentation alcohol to industrial uses: the large increase in plant capacity for fermentation alcohol, a slump in demand for alternate fuels usage, and lower cost compared to synthetic ethanol as long as raw material corn prices remain relatively low.

This overhang of fermentation ethanol on the industrial market continues to undermine real selling price for synthetic ethanol. In general, analysts estimate that fermentation ethanol is about 20 cents a gal cheaper for many solvent uses compared to the list price for synthetic ethanol. Therefore, especially in spot sales, synthetic ethanol producers are not always getting their list price.

Thus with the prospect of a U.S. recession, no real growth in most uses, rising imports and U.S. production of fermentation ethanol, and rising costs of ethylene, synthetic ethanol producers expect no better in 1982 than they got in 1981.

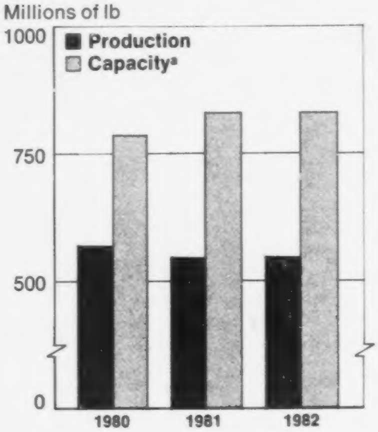
Key Chemicals

CH_2Cl_2

Methylene chloride

- ***Demand low***
- ***Capacity high***
- ***Prices under pressure***

PRODUCTION/CAPACITY



[a] First quarter, varies with product mix.

HOW MADE

Chlorination of methane; hydrochlorination of methanol, then chlorination of methyl chloride

MAJOR DERIVATIVES

None of any size

MAJOR END USES

Paint remover 30%, aerosol propellants 20%, degreaser 10%

FOREIGN TRADE

Exports—dropping sharply to about 30 million lb in 1981; imports—up to some 60 million lb in 1981

PRICES

List price 30.5 cents per lb

COMMERCIAL VALUE

$160 million for 1981 production

U.S. producers of chlorinated methanes hope the rest of these products will have a better year coming up than will methylene chloride. Companies might wish that methylene chloride output in 1981 and 1982 will match 1980, but that probably won't happen. Production likely will be off a bit each year, and some plant capacity for methylene chloride will be shifted to more profitable products.

In 1981, production could total 550 million lb, down from about 560 million lb in 1980. For 1982, some producers forecast the same level as in 1981 but without much conviction. A more likely total for 1982 will be 525 million to 540 million lb.

Plant capacity at this production rate certainly will not be strained. A rough estimate of total U.S. methylene chloride capacity is 825 million lb a year. However, depending on the producer, capacity is quite variable.

Some producers may be able to shift production by 25% of nameplate capacity either way, depending on the market situation. Hence, actual total capacity may range between 600 million lb and 1 billion lb with different product mixes.

A major reason for small declines in methylene chloride output in 1981 and 1982 is an import surge starting about mid-1981. Such imports, rumored being sold at discounts of 10% or so off U.S. list prices, are expected to continue coming in over the rest of 1981 and 1982.

At the same time, methylene chloride exports are declining, adding another reason for a decline in U.S. production. The new strength of the U.S. dollar is tending to hurt exports of all U.S. products, and methylene chloride is no exception.

Domestically, only small changes are occurring in this solvent's use pattern. Volume is holding up in its largest use as an ingredient of paint remover. Demand here is subject to some impact from inventory shifts in the finished product. This happens because much paint remover is sold under small-volume private labels. This results in middleman distributors of methylene chloride being important in the paint remover market. Many of the small formulators make paint removers only intermittently during the year and need a periodic supply source.

Paint remover containing methylene chloride goes into both industrial and consumer markets. In both, its advantages of high solvency, relatively low toxicity, and exemption from many restrictions in air pollution control rules help to spur growth. Offsetting these pluses currently is the U.S. recession, which reduces most industrial operations and discretionary consumer spending by do-it-yourself furniture refinishers. Because of the natural lag between eventual upswings in retail sales and in chemical production, growth in this application of methylene chloride probably will be small until 1982.

Next in size among uses of methylene chloride is the aerosol propellant outlet. Growth in this outlet has been good because of the shift away from rival chlorofluorocarbons. However, growth in this "capture" market, in response to chlorofluorocarbons' suspected damage to atmospheric ozone, is shrinking rapidly. The rate is still good, but in a year or so it may level off, tied after that to overall growth in aerosol products.

In another "capture" market, methylene chloride also replaces trichloroethylene as a metal degreasing agent. Here, too, much of this change already has taken place. Growth in this application is expected to be small from now on.

For the same reason that it is used in paint removers, methylene chloride finds use as a blowing agent for making polyurethane foams. In the past this use has had good growth, but this year the rate has fallen off with the decline in housing, an important market. After a lag to allow inventory changes, this use would pick up with any recovery in housing.

Many other uses of methylene chloride also hinge on its solvency properties. None of these are large enough to have a big impact on its total consumption.

Methylene chloride's many separate markets combine to give it a weak outlook until probably after 1982. Then this chemical might recover some of its old promise and get back on the track of overtaking carbon tetrachloride as the largest-volume chlorinated methane.

Brazil targets more ethanol for chemicals

To help country fulfill goal, Oxiteno and U.S.'s Halcon SD Group plan joint R&D effort to develop new routes to ethanol-derived chemicals

There is, as the old song says, an awful lot of coffee in Brazil.

What the song doesn't mention is that there also is an awful lot of sugar, much of which is being converted into ethanol under the country's heralded alcohol fuels program, or PROALCOOL, as it's called in Brazil.

Despite some recent setbacks—the country's stumbling economy has cut back on production of all cars, including those designed to run exclusively on alcohol, and the all-alcohol car has run into more than its share of operating problems—Brazil is pushing ahead toward its goal of producing 10.7 billion L per year of ethanol by 1985. Output will be about 4 billion L this year.

If Brazil even comes close to reaching its 10.7 billion L goal by 1985, its already substantial ethanol-based chemical industry probably will have about 1.5 billion L, or about 400 million gal, of ethanol to use as a chemical feedstock.

For Brazil's chemical industry, the PROALCOOL program is important in more ways than one. Not only will increasing volumes of ethanol become available to use directly as a raw material for a wide range of chemicals, but the large volumes of ethanol earmarked for fuel will free a lot of additional naphtha for Brazil's petrochemical complexes. Meanwhile, basing at least part of its chemical output on ethanol will enable the country to fulfill another of its high-priority objectives—to decentralize production and establish new industries in poor, less-developed regions of the country.

Brazil, then, has a lot riding on an expanded alcohol-based chemical industry. So does Oxiteno S.A. (São Paulo) and the Halcon SD Group. Oxiteno, Brazil's largest privately held chemical company, and Halcon SD recently signed an agreement for a joint program of research and development that will concentrate on developing existing and new processes using ethanol as feedstock. Oxiteno will do most of the work under the five-year program at its pilot plant facilities in São Paulo. Halcon SD will support the program with its own laboratory work in the U.S.

Halcon SD and Oxiteno are no strangers. Halcon SD already has a 10% equity interest in Oxiteno. And Halcon SD technology is being used at two Oxiteno plants in Brazil to produce ethylene oxide, ethylene glycol, and other ethylene oxide derivatives.

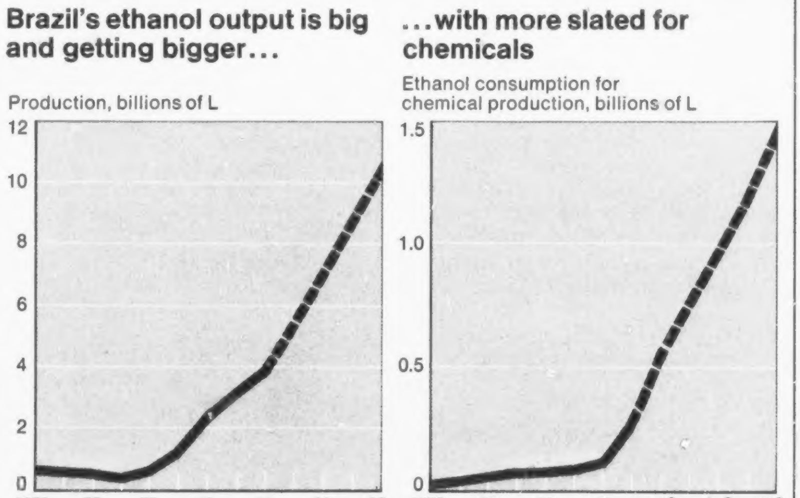
As Halcon SD president and chief executive officer Robert Malpas explains it, the joint R&D effort will concentrate on developing new routes to make ethanol-derived chemicals. "Most of these chemicals already are in the textbooks," he says. "We want to develop new, more economical methods of producing them."

New technology that comes out of the joint R&D program will be patented in the names of both parties. Initially, Oxiteno will use this technology in Brazil. It also has exclusive rights to license it to third parties in Brazil.

Abichara: technology will be developed

Halcon SD gets to use the technology in plants that it or its affiliates own or operate as well as third-party licensing rights in all areas of the world outside Brazil. The most promising areas, says Malpas, probably will be oil-poor but biomass-rich countries in Latin America, Asia, and Africa.

Araguarayno Abichara, director of Oxiteno, thinks that programs such as the joint Oxiteno-Halcon effort are important, not only for his company, but for all of Brazil. It's one thing to plan on having 1.5 billion L of ethanol



Brazil's ethanol output is big and getting bigger...

...with more slated for chemicals

a Petrobras estimates. **Source:** Petroquisa available for chemical production in 1985, with prospects of even much greater volumes in the next decade. But it also is necessary, he says, to be able to use this raw material economically. That, says Abichara, is why it is important to start now to develop the technology that will make ethanol-derived chemicals competitive with petrochemicals.

Right now, most of them aren't. This year, Brazil will use an estimated 600 million L, or about 160 million gal, of ethanol to produce a wide variety of chemicals, including ethylene, acetaldehyde, octanol, and butanol. With the possible exception of acetaldehyde, none of these ethanol-derived products are competitive with their petrochemical counterparts without a subsidy provided by the Brazilian government.

Abichara is confident that technology will be developed to make these ethanol-based chemicals competitive. But Oxiteno isn't waiting for that technology to be tied up in a neat package. In Alagoas state in northeastern Brazil it already is building plants to produce 55,000 metric tons per year of acetaldehyde, 14,000 metric tons per year of acetic acid, 30,000 metric tons of butanol, and 10,000 metric tons of butyl acetate. All are based on ethanol.

Oxiteno's plants in Alagoas will help foster Brazil's plan to use the PROALCOOL program to divert chemical production away from existing petrochemical complexes. Salgema Industrias Quimicas, a subsidiary of Petrobras, the state-owned oil company, already is operating a 60,000 metric-ton-per-year ethylene-from-ethanol plant at Maceio in the state of Alagoas. The Salgema plant is part of a complex that includes chlorine, caustic, and ethylene dichloride.

Meanwhile, in Pernambuco state just to the north of Alagoas, two other ethanol-based chemical projects are shaping up. Coperbo has a plant at this site to produce butadiene from ethanol, but it is being converted to ethylene and acetaldehyde. The company also is planning to produce vinyl acetate (from the ethylene) and acetic acid.

Elekeiroz Nordeste already produces butanol and octanol from ethanol in Pernambuco. These units are being expanded.

Plants such as these, based on ethanol, never will replace Brazil's huge petrochemical complexes. But they will play an important role in the country's overall chemical industry.

Earl Anderson, New York

Tough decade ahead for aromatics

Outlook for the aromatics business in the 1980's is "somber," according to BP Chemicals' Michael H. T. Janes. "It will be a tough decade, with low [plant] utilization rates in all but the occasional boom year," he believes. "I am predicting a pessimistic situation in world demand, with the likelihood that growth in markets will not match what we saw in the 1970's," he says.

Janes, who is purchasing manager at his company's headquarters in London, presented his thoughts on the subject at the European Chemical Market Research Association's annual conference, which this year was held in Cannes, France. "If you're losing your shirt today, hang onto your pants tomorrow," he quipped.

A number of pitfalls lie ahead. "Markets will be unstable and face competition from producers willing for various reasons to accept unremunerative prices. Feedstock costs may be reasonably stable up to mid-decade, but that is far from guaranteed. This will represent some change for the U.S., which has enjoyed relative prosperity over the period of crude-oil regulation, assisted, at least up to 1979, by high-octane demand for toluene and xylenes. For Western Europe and Japan, however, these problems will not be new or different from what we have experienced since 1974."

Demand will depend largely on the level of economic growth in the years to come. "It is a feature of the industry that when gross domestic product sneezes, aromatics catch a cold," Janes observes. "Plant utilization rates will be very low if there is a setback to future growth in GDP, an outcome that would impose severe problems for the industry, and call for substantial retirement of older capacity." In addition, there is the disruption that will stem from emergence of new producing countries, mainly Mexico and Saudi Arabia, and new plants planned for Western Canada.

Looking at the GDP growth prospects for the 24 industrialized countries that make up the Organization for Economic Cooperation & Development (OECD), "my conclusion is that the best outcome at 3% per year average will be below the [3.2% per year] average achieved in the 1970's," Janes says. "But there is a real prospect of a serious decline in world economic growth, even to an average rate as low as 1.5% per year.

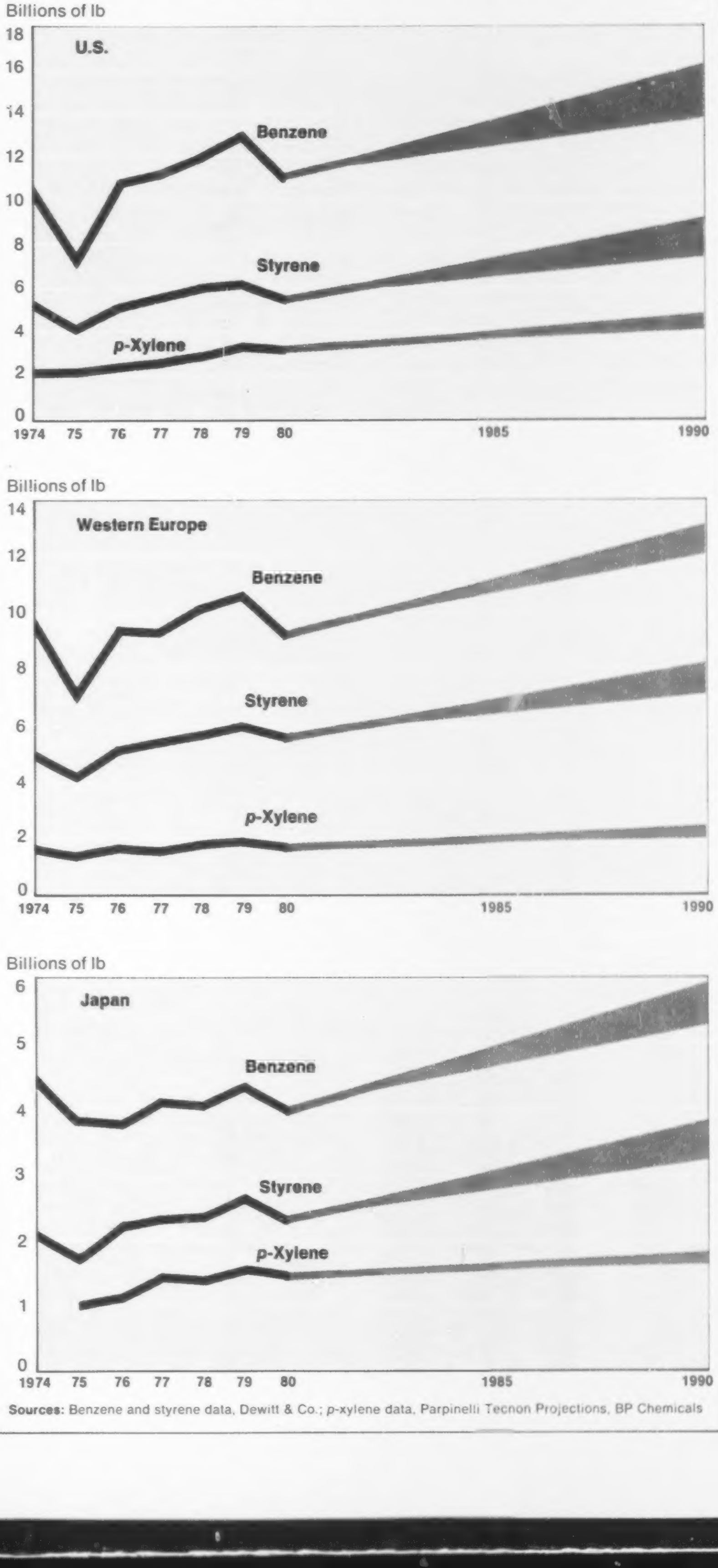
"The actual out-turn is going to be of the utmost importance to aromatics producers in the industrialized regions of the world. The aromatics industry is faced with an unstable and a cyclical demand pattern. I think that the 1980's will exhibit more, rather than less, instability than the 1970's, particularly if overall economic growth comes out at the lower end of the span. Low growth means larger interruptions, and larger cyclical savings in demand. This cyclical instability presents the forecaster with almost insuperable problems, because our normal measure, the annual average growth rate, can scarcely do justice to large deviations from the trend."

For the U.S., GDP growth might range between a per-year average of 1.25 to 2.25%. This would be slightly below Western Europe's expected annual average range of 1.5 to 3%. Growth in Japan, on the other hand, likely will average a stronger 3.5 to 5% per year. With such a range of growth rates in view, Janes looks at the possible trends in consumption of benzene, styrene, and *p*-xylene in the various geographic regions, consumption being local production and imports minus exports.

In the U.S., growth of these aromatics could outpace that of GDP. For instance, if, as Janes thinks, benzene demand rises at an average yearly rate of 1.5 to 3%, the 1990 total will lie between a low of 14 billion and a high of 16.2 billion lb. If styrene demand grows 2.5 to 4.5% annually, 1990 consumption will range from 7.7 billion to 9.3 billion lb. "Styrene growth is particularly dependent on some revival of the U.S. auto industry using more plastic components per vehicle to improve mileage performance," he remarks. *p*-Xylene, benefiting from a relatively stronger U.S. domestic synthetic fiber industry, might expand 2 to 3.5% per year, raising 1990 consumption to 4.1 billion to 4.8 billion lb.

Throughout Western Europe, Janes sees a benzene demand growth trend of 2 to 3% per year, much in line with that of GDP, to a 1990 total of 12.2 billion to 13.4 billion lb. Styrene could be slightly ahead of GDP at an annual average of 2 to 3.5%, and a 1990 consumption of 7.1 billion to 8.2 billion lb. Western Europe's *p*-xylene outlook is poor, however, both because of the weak state of the synthetic fiber industry there, and weak exports of fiber intermediates. He selects a likely growth of 0.5 to 2.5%

Consumption of aromatics in U.S., Western Europe, and Japan is forecast to grow steadily despite problems



Sources: Benzene and styrene data, Dewitt & Co.; *p*-xylene data, Parpinelli Tecnon Projections, BP Chemicals

annually, with a 1990 consumption of 1.9 billion to 2.3 billion lb.

"For similar reasons," Janes adds, "demand growth both for cyclohexane, and nylon from phenol, are held to be little above zero at best, and negative at worst. *o*-Xylene demand, which looms much larger in the spectrum of aromatic products in Western Europe than elsewhere, is vulnerable to loss of export markets downstream from the mid-1980's, but may keep pace with GDP over the decade as a whole."

Growth of Japan's aromatics consumption hardly will match the expected substantially higher GDP pattern there. For instance, Janes sees benzene's annual growth ranging from 2 to 3.5%, with a 1990 total of 5.2 billion to almost 6 billion lb. "This disparity reflects Japan's relative lack of indigenous energy resources."

Styrene consumption growth in Japan might match that of the U.S.'s 2.5 to 4.5% per year, although in terms of quantity the 1990 total would be much less, somewhere between 3.2 billion and 3.9 billion lb. *p*-Xylene growth is seen moving at a sluggish 0.5- to 1.5%-per-year rate to 1.6 billion to 1.8 billion lb in 1990. *p*-Xylene, and also cyclohexane, demand in Japan "is particularly dependent on derivative exports to developing countries, which are regarded as vulnerable," according to Janes.

There is little doubt that if all the new aromatics facilities being considered by developing countries come to fruition, their output will have a decidedly adverse effect on established producers. Citing projections made by the United Nations Industrial Development Organization earlier this year, Janes notes that about 7 billion lb of benzene capacity might be expected in 1984, almost double the 1979 level. The increase would be even greater for the xylene isomers, with capacity moving up 1.5 times from the 1979 total to 4.7 billion lb in 1984. The plants will be spread throughout Asia, Latin America, the Middle East, North Africa, and China, with African and Middle Eastern countries appearing as new producers.

"Some of the new capacities will be in countries where overseas indebtedness is the main constraint on economic development," Janes says, "and there are inducements from governments or state-owned feedstock suppliers to operate near capacity for the sake of exports, or import savings, regardless of returns. The consequent pressure on the BTX [benzene, toluene, and xylenes] markets of the industrialized regions will be felt particularly by the dealkylators, and we must expect some capacity to be put on permanent standby. Utilization rates may be somewhat improved in Western Europe if naphtha cracking capacity is retired there, taking some associated extraction capacity with it."

Eastern Europe also looms large as a future source of aromatics. "Projects not matched by growth in [local] consuming capacity imply an additional 1.1 billion lb of net benzene exports by 1985," Janes notes. He admits to uncertainties of investment planning and plant construction schedules, which will diminish this figure substantially. "But we should allow for at least a doubling of 1980's 220 million lb net exports of benzene from Eastern Europe, bearing in mind that certain compensation deals will be honored," he reasons.

As for the ortho and para isomers of xylene, two large projects in the U.S.S.R. scheduled for startup next year will have combined capacity exceeding 660 million lb of each isomer annually. "The bulk of this capacity doubtless will be committed domestically, but some tonnage is committed under compensation to users in Western Europe," Janes says.

"The new competition is going to be an additional destabilizing influence as traditional importing countries emerge as exporters," Janes fears. This destabilizing influence will be more acute if world economic growth is at a low level.

"Utilization rates [of existing plants] in the industrial regions are going to be seriously depressed by imports of BTX and of derivatives. But I am not convinced that this will be too disastrous for aromatics profitability in Europe or Japan. Imports of benzene may be a preferred alternative to operating higher-cost hydrodealkylation units. And imports of low-priced toluene and xylenes may be preferred to reforming additional naphtha, especially for areas that depend on imported crude, and possibly face refinery imbalances and shortage of the light end of the barrel."

Janes see the xylene isomers "giving reasonable returns on historical capital in most years through the 1980's. There is considerable scope for further market penetration by polyester fibers in the populous countries of the Far East, particularly China. Some additional impetus should derive from higher growth rates expected for polyester film and resins still in the stage of market development. World demand for *p*-xylene should continue to grow at around 4 to 5.5% per year on average up to 1985, thereby creating the headroom for the new capacities."

By his own admission, Janes is less gloomy about the outlook for the xylene isomers in the 1980's than he is about styrene, which consumes about half the global benzene output. "Profits on styrene are more sensitive to utilization rates, and producers are more concerned about their share of the merchant market. The temptation to defend or extend that share by aggressive price tactics when utilization rates are low is very powerful. Whereas BTX prices remain fairly resilient to low market demand through reduced production by hydrodealkylation and through intermanufacturer purchases, styrene prices may erode at the very point where each unit of output has to bear a higher overhead cost as producers strive to maintain plant loadings.

"Looking further ahead, styrene producers must remain concerned about market disruption from competitors with an inside track on raw materials. New producing areas, such as Mexico, Western Canada, and the Middle East, are not content to be simply producers of low added-value aromatics. To the extent that they have ethane, which they wish to ship to the world's markets, they want to add an ethylene component."

As might be the case with the primary BTX aromatics, Janes isn't confident about the prospects of responsible marketing policies being followed by these new producers, even where large international oil companies have a participation. "It seems to be the clear intention of many host governments to use low feedstock values as an instrument of market penetration on the pretext that this is needed to compensate for higher costs of plant construction as compared, say, to the U.S. Gulf Coast. But to make total costs per unit of output level on this basis would mean introducing substantial differences in incremental costs on a product like styrene.

"There is, perhaps, a small crumb of comfort," Janes says. "If styrene is to be used as a vehicle for shipping ethane to the world's markets, in any given situation preference would be given to polyethylene or ethylene glycol over styrene, whose large aromatic content quite easily can earn world prices by being shipped as naphtha." □

Stronger role for U.S. chemical firms in Europe

"We have no doubt that involvement of U.S. chemical companies will continue in Europe, and, in fact, expand from present levels. There is good potential for growth in Europe."

Such is the contention of Richard F. Bechtold, Dow Chemical Europe's regional and planning executive vice president. He shared his views with participants in the European Chemical Market Research Association's meeting in Cannes, France. The positive stance he takes on the role of U.S. chemical companies in Europe in the years immediately ahead is all the more refreshing in light of Europe's depressing economic climate, and the severe overcapacity in many parts of its petrochemical industry.

C&EN staff photo

Bechtold: future is in specialties

Bechtold is convinced that the "flexibility" that characterizes American companies will serve as a spur to local West European producers to develop even more efficient and integrated manufacturing operations. The influence isn't one-sided, he is quick to note. He points to "the positive catalytic effect which European companies have exerted on the U.S. marketplace due to their presence in North America."

He holds that those U.S. chemical companies that are still strongly competitive in Western Europe in 1990 will have, with few exceptions, some common characteristics. "One of these characteristics will be the approach to Europe as a unified market to be served from within.

Chemical & Engineering
NEWS
November 16, 1981

Companies, universities set up new research funding channel
Page 45

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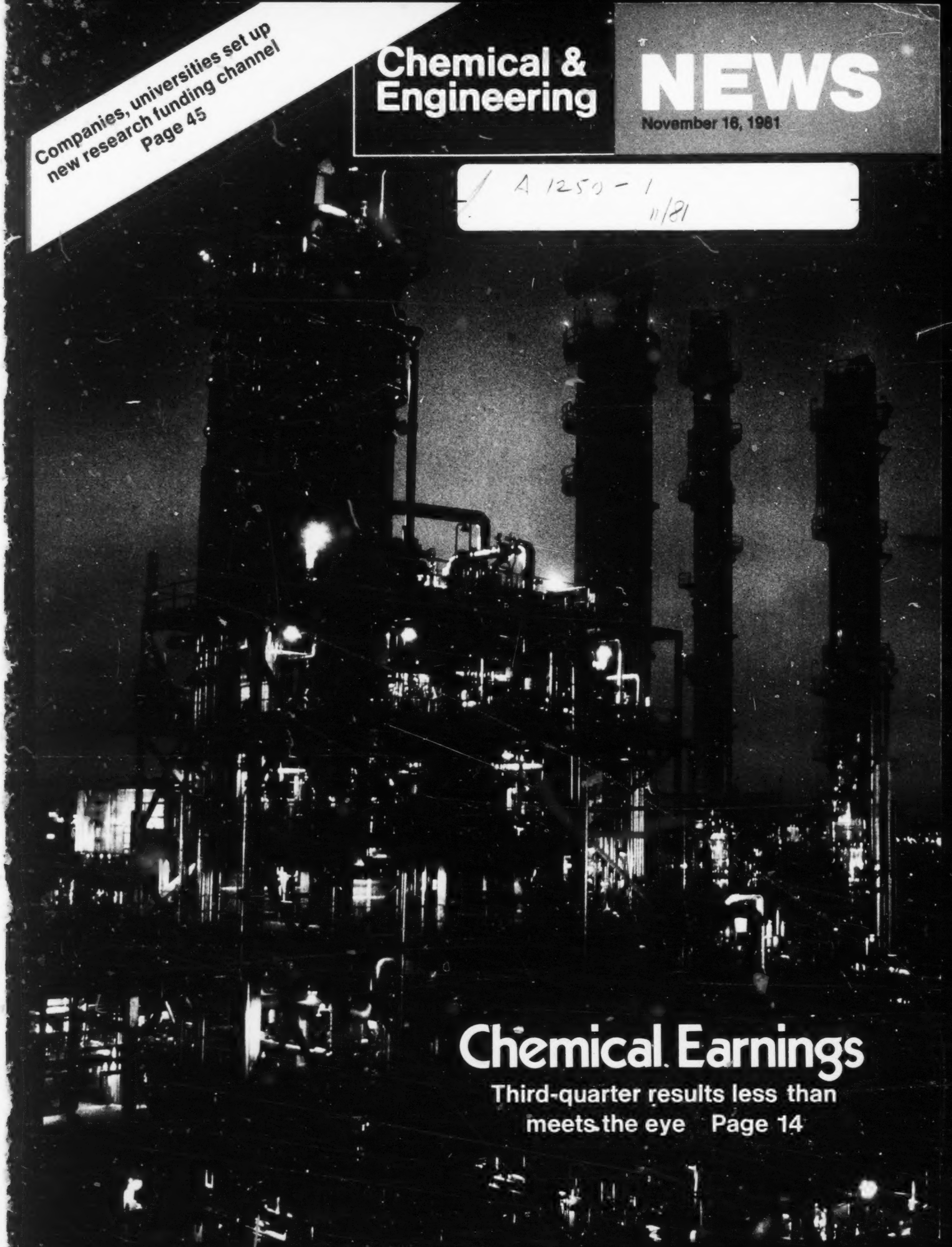

Chemical Earnings

Third-quarter results less than meets the eye Page 14

November 16, 1981
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Chemical & Engineering NEWS

Cover: Du Pont methanol plant at Deer Park, Tex.

4 Letters
7 Editor's Page

Concentrates
13 Business
26 Government
38 Science/Technology

The Departments
55 New Products
65 ACS Comment
66 Meetings
88 Newscripts

News of the Week

- ***Recession has hit the chemical industry;*** *volume is down 5 to 10% and fourth-quarter prospects aren't good.* ***Page 8***
- ***Study of peer review process*** *by National Academy of Sciences finds little bias against grant seekers.* ***Page 8***
- ***Manipulable teratocarcinoma cells*** *act normally when put back into mouse embryos, transmit genetic traits.* ***Page 9***
- ***Corning Glass and Kroger*** *supermarket chain plan joint venture to turn by-product whey into bakers' yeast.* ***Page 9***
- ***General Electric*** *will spend $1.5 billion on an engineering plastics complex to be built near Montgomery, Ala.* ***Page 10***
- ***Further evidence found*** *that toxins of the tricothecene family are being used in warfare in Southeast Asia.* ***Page 10***

Business

- ***Major U.S. chemical firms show a scant 11% gain in profits*** *in the third quarter over a weak third quarter in 1980.* ***Page 14***

International

- ***Combined earnings of Canada's*** *four largest chemical companies are down in third quarter even though sales are up.* ***Page 22***
- ***Ethylene derivatives' global trade pattern*** *expected to change by 1990; net exporters predicted to shift to imports.* ***Page 23***
- ***West European petrochemical industry*** *faces pitfalls for investment strategies to balance supply and demand.* ***Page 24***

Government

- ***EPA's publication clearance policy*** *exempts from review scientific papers going into peer-review journals.* ***Page 28***
- ***Chemical industry faces challenge*** *to react responsibly to new federalism.* ***Page 30***

Science

- ***Microscale techniques*** *enable researchers to measure cell currents accurately, synthesize proteins from living cells.* ***Page 40***

Science Update

- ***C&EN takes a look*** *at the areas of inorganic chemistry that have changed most dramatically in recent years.* ***Page 42***

Education

- ***Council for Chemical Research*** *will raise industry funds for academic R&D.* ***Page 45***

Technology

- ***Japanese seek U.S. C_1 chemistry technology*** *to shave competitive loss caused by high costs of imported oil.* ***Page 57***
- ***U.S. market for filtration equipment*** *hit $1.8 billion in 1980.* ***Page 59***

Chemical earnings post drab third quarter

Profits at major chemical firms were up only 11% over last year's very weak third quarter: gain for full year likely won't exceed 5%

William J. Storck, C&EN
New York, and William F.
Fallwell, C&EN Washington

U.S. chemicals had a lackluster three months in the third quarter. Although earnings at the 40 largest chemical companies increased 11% over the same period last year, they were going up against a quarter that was just beginning to recover from the short recession of 1980. At the same time, petrochemical earnings at oil companies are a drag on their parent companies and earnings at the diversified companies are mediocre at best.

In spite of what looks like a good year-to-year gain for the 40 largest chemical companies, things are not so good as they may seem. Earnings for the 40 companies, although up 11% from last year, are bucking a very weak third-quarter 1980, which itself was off 16% from 1979 third-quarter earnings. Thus, earnings at the largest chemical companies still are below 1979 third-quarter levels.

The outlook for full-year 1981, therefore, does not look strong. Through the first nine months of this year, chemical earnings increased just 7% from the same period of 1980. Since the industry will be going up against a strong 1980 fourth quarter to finish the year, it now looks as if the 40 chemical companies will be lucky to get an earnings gain of more than 5% for the full year. And if signs that the chemical economy is still slowing are correct, the industry may be fortunate to garner an increase of more than 5%.

This is a far cry from the conventional wisdom not too long ago that the second half of 1981 would be strong and that the industry would finish with a gain for the year of at least 10 to 15%. Some estimates had put the gain even higher.

The problems of the chemical industry are largely the same as they have been for some time—extremely poor construction and automotive markets. These especially affect plastics, but they also are taking their toll on many other chemical products. As a result of the poor end-use demand, capacity use in many areas of the chemical industry is in poor shape and prices are weak.

The one bright spot seems to be fibers, but even here the performance is erratic. Those fibers that go into

Chemical industry leaders for third-quarter 1981 . . .

Sales				Earnings[a]			Profitability		
Rank		$ Millions	Rank 1980		$ Millions	Rank 1980		Earnings as % of sales	Rank 1980
1	Du Pont	$ 3671.0	1	Du Pont	$134.0	3	Freeport-McMoRan	21.8%	1
2	Dow Chemical	2923.9	2	Union Carbide	137.8	2	Nalco Chemical	12.6	5
3	Union Carbide	2424.7	3	Dow Chemical	108.5	1	Great Lakes Chemical	10.8	3
4	Monsanto	1633.8	4	W. R. Grace	97.1	4	International Flavors	10.1	2
5	W. R. Grace	1587.6	5	Allied Corp.	80.0	5	International Minerals	8.9	7
6	Allied Corp.	1544.0	6	Monsanto	55.9	11	Chemed	8.6	8
7	Celanese	955.0	8	Diamond Shamrock	51.8	8	Mallinckrodt	7.5	9
8	American Cyanamid	868.0	7	PPG Industries	49.7	7	Petrolite	7.5	6
9	PPG Industries	847.5	9	Freeport-McMoRan	44.3	6	Loctite	7.2	22
10	Diamond Shamrock	823.4	11	American Cyanamid	42.0	10	Air Products	7.1	15

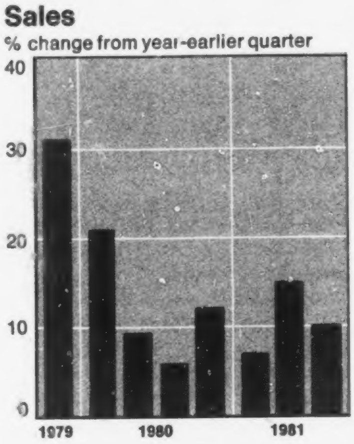
. . . and for first nine months 1981

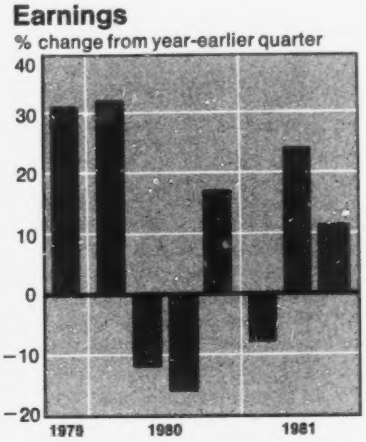
Sales				Earnings[a]			Profitability		
Rank		$ Millions	Rank 1980		$ Millions	Rank 1980		Earnings as % of sales	Rank 1980
1	Du Pont	$11,277.0	1	Du Pont	$609.0	3	Freeport McMoRan	21.0%	1
2	Dow Chemical	8,887.7	2	Union Carbide	509.2	2	Great Lakes Chemical	13.1	3
3	Union Carbide	7,739.2	3	Dow Chemical	418.4	1	Nalco Chemical	12.2	5
4	Monsanto	5,389.4	4	Monsanto	325.7	5	International Flavors	11.7	2
5	W. R. Grace	4,761.5	5	W. R. Grace	279.6	4	Stauffer Chemical	9.3	13
6	Allied Corp.	4,711.0	6	Allied Corp.	251.0	6	Petrolite	9.1	6
7	Celanese	2,868.0	8	PPG Industries	166.2	8	Chemed	9.0	8
8	PPG Industries	2,550.0	9	Diamond Shamrock	163.5	7	Mallinckrodt	8.0	11
9	Diamond Shamrock	2,523.3	11	Freeport McMoRan	133.3	9	Air Products	7.8	12
10	American Cyanamid	2513.7	7	American Cyanamid	131.3	11	Lubrizol	7.8	4

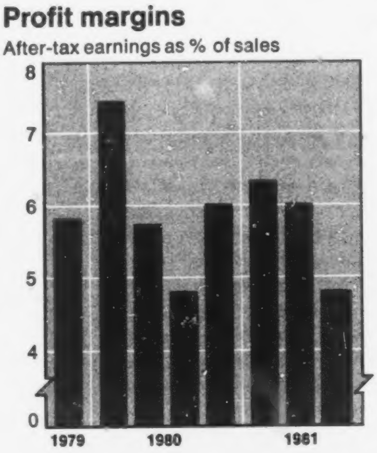
[a] After taxes. Note: For 40 chemical companies listed on page 16.

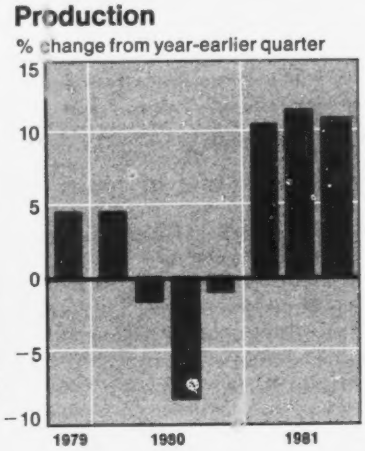
Chemical Industry Third-Quarter Results

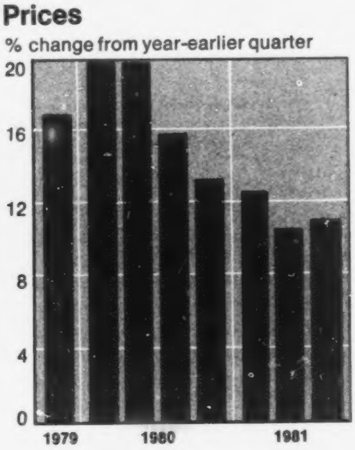
- **Sales increased 10%**
- **Earnings rose 11%**
- **Causing flat profit margins**
- **Production increased 11%**
- **As did prices**


Sales
% change from year-earlier quarter

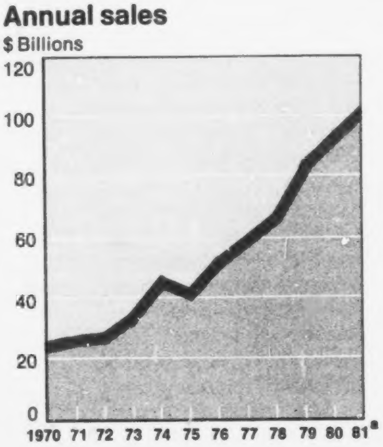

Earnings
% change from year-earlier quarter

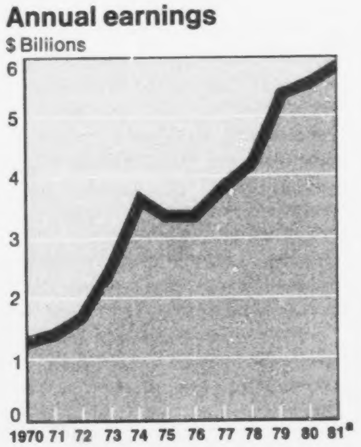

Profit margins
After-tax earnings as % of sales

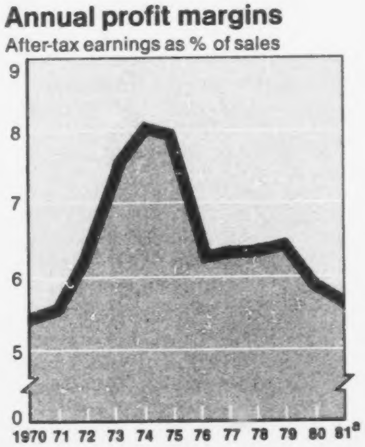

Production
% change from year-earlier quarter


Prices
% change from year-earlier quarter

1981 earnings now will be up only 5%; sales likely will increase 10% to more than $100 billion, driving average profit margin down to 5.7%


Annual sales
$ Billions


Annual earnings
$ Billions


Annual profit margins
After-tax earnings as % of sales

[a] C&EN estimates. **Note:** All sales, earnings, and profit margin data are based on the combined performance of the 40 largest chemical makers listed on page 16.

Third-quarter profit margins at chemical companies stayed at last year's low level

	THIRD-QUARTER 1981						NINE-MONTHS 1981			
	Sales	Earnings	Change from 1980		Profit margin[a]		Sales	Earnings	Change from 1980	
	($ millions)		Sales	Earnings	1981	1980	($ millions)		Sales	Earnings
Du Pont[d]	$ 3,671.0	$ 164.0	15%	91%	4.5%	2.7%	$11,277.0	$ 609.0	10%	21%
Dow Chemical	2,923.9	106.5	16	−32	3.7	6.4	8,887.7	418.4	13	−26
Union Carbide[e]	2,424.7	137.8	2	−10	5.7	6.5	7,739.2	509.2	6	−3
Monsanto[f]	1,633.8	55.9	6	89	3.4	1.9	5,389.4	325.7	10	5
W. R. Grace	1,587.6	97.1	6	41	6.1	4.6	4,761.5	279.6	8	28
Allied Corp.[g]	1,544.0	80.0	17	21	5.2	5.0	4,711.0	251.0	16	21
Celanese	955.0	34.0	22	55	3.6	2.8	2,868.0	111.0	18	34
American Cyanamid[h]	868.0	42.0	9	4	4.8	5.0	2,513.7	131.3	7	19
PPG Industries	847.5	49.7	11	4	5.9	6.2	2,550.0	166.2	10	17
Diamond Shamrock	823.4	51.8	6	4	6.3	6.4	2,523.3	163.5	10	3
B. F. Goodrich[i]	822.2	13.7	5	57	1.7	1.1	2,431.1	42.6	6	9
Hercules	690.0	27.0	19	21	3.9	3.8	2,070.0	96.1	12	16
Olin	489.9	17.7	13	46	3.6	2.8	1,556.0	79.1	11	29
Williams Cos.	478.6	13.9	−8	−45	2.9	4.8	1,552.4	103.4	−1	−3
International Minerals	448.3	39.9	3	−1	8.9	9.3	1,531.9	116.7	10	−8
Ethyl Corp.	448.2	21.0	4	9	4.7	4.5	1,326.9	65.1	1	nc
Rohm & Haas[j]	448.0	21.6	11	−4	4.8	5.6	1,472.1	73.9	13	−4
Air Products	403.0	28.8	9	24	7.1	6.3	1,203.6	93.7	9	11
Stauffer Chemical	343.3	14.3	4	218	4.2	1.4	1,349.8	125.3	6	33
Witco Chemical[k]	326.1	9.6	9	4	2.9	3.1	985.1	25.8	14	−16
Akzona	288.2	5.0	21	def	1.7	def	911.1	12.5	18	346
Pennwalt	287.5	9.1	nc	nc	3.2	3.2	891.1	29.5	3	−6
Reichhold Chemicals[l]	246.1	3.2	15	−32	1.3	2.2	739.2	12.7	11	40
Lubrizol	225.9	14.9	1	−47	6.6	12.6	690.9	54.0	nc	−38
Freeport-McMoRan	202.8	44.3	6	−11	21.8	26.0	635.7	133.3	24	−2
Thiokol	178.9	9.2	9	42	5.1	4.0	529.0	26.2	15	12
Nalco Chemical	168.1	21.1	7	15	12.6	11.8	489.0	59.9	8	15
Mallinckrodt	122.0	9.2	14	11	7.5	7.7	370.7	29.5	13	12
International Flavors	109.5	11.1	2	−28	10.1	14.4	353.2	41.3	nc	−21
Liquid Air[m]	104.9	6.8	8	5	6.5	6.7	323.5	23.2	5	10
Chemed[n]	90.6	7.8	14	21	8.6	8.1	263.3	23.6	15	17
H. B. Fuller	83.5	3.8	13	98	4.5	2.6	246.3	10.4	13	65
Petrolite	74.3	5.6	13	−19	7.5	10.5	220.1	20.1	16	6
Crompton & Knowles	60.8	1.7	5	42	2.8	2.1	186.8	5.9	3	16
Loctite	54.5	3.9	12	50	7.2	4.7	166.8	9.5	10	−26
First Mississippi	53.2	—	−8	−99	—	6.6	254.5	17.5	31	2
Stepan Chemical[n]	50.1	1.4	27	−33	2.8	5.3	155.6	4.5	34	8
Essex Chemical[o]	40.9	2.3	−3	35	5.6	4.0	132.8	5.7	18	50
Great Lakes Chemical	40.8	4.4	29	1	10.8	13.6	110.1	14.4	20	6
Philip A. Hunt	27.5	1.5	7	36	5.5	4.3	82.2	2.8	3	−38
Total 20 largest companies	**$22,176.5**	**$1028.3**	**13%**	**10%**	**4.6%**	**4.5%**	**$68,699.3**	**$3786.6**	**10%**	**8%**
Total 20 other companies	**$ 2,510.1**	**$ 166.3**	**9%**	**−4%**	**6.6%**	**7.5%**	**$ 7,751.9**	**$ 536.5**	**11%**	**−2%**
GRAND TOTAL	**$24,686.6**	**$1194.6**	**10%**	**11%**	**4.8%**	**4.8%**	**$76,451.2**	**$4323.1**	**10%**	**7%**

a After-tax income as a percentage of sales. **b** Fully diluted before nonrecurring items and extraordinary charges for operations. **c** As of Oct. 30. **d** Excludes Conoco results for third quarter. **e** Excludes $217.3 million nonrecurring credit in first nine months 1980. **f** Excludes $67.7 million nonrecurring gain in third-quarter 1981. **g** Excludes net nonrecurring gain of $38 million in third-quarter 1981. **h** Includes nonrecurring change in 1980. **i** Excludes $8.7 million nonrecurring gain in third quarter. **j** Includes nonrecurring item. **k** Excludes $1.6 million nonrecurring

construction markets such as carpet nylon and polyester are having a tough go of it. Apparel fibers are doing a little better. The theory is that because people cannot buy the really big ticket items such as automobiles they will content themselves with clothing.

Add to the problems of construction and automobiles, the poor overseas economy, and the strengthening U.S. dollar against other currencies and it is easy to see why the chemical economy is in the shape that it is. And the problems plaguing the industry do not seem likely to go away soon. It is a good bet that the U.S. chemical economy will not begin a recovery until at least the second quarter of next year—about nine months after the time that was originally estimated for a turnaround.

Even then, the growth probably will not be spectacular. And, not until 1983 will U.S. chemicals begin to see performance matching that of a few years ago.

The 11% gain in the third quarter brought earnings for the 40 companies up to $1.19 billion. At the same

NINE-MONTHS 1981 Profit margin[a] 1981	NINE-MONTHS 1981 Profit margin[a] 1980	12-MONTH RUNNING DATA Change from 1980 Sales	12-MONTH RUNNING DATA Change from 1980 Earnings	12-MONTH RUNNING DATA Profit margin[a] 1981	12-MONTH RUNNING DATA Profit margin[a] 1980	STOCK MARKET DATA[c] Earnings per share[b] 3rd qtr	Earnings per share[b] Recent 12 months	Stock price Oct. 30	Stock price Recent 12 months High	Stock price Recent 12 months Low	Price earnings ratio Oct. 30	Annual indicated dividend	Dividend yield, % of price
5.4%	4.9%	11%	37%	5.6%	4.6%	na	na	$40½	$56	$35¾	na	$2.40	5.9%
4.7	7.2	6	−18	5.6	7.3	$0.57	$ 3.16	25⅞	39	23⅜	8	1.80	7.0
6.6	7.2	7	−3	6.1	6.7	2.02	10.15	47¾	62⅛	44⅞	5	3.40	7.1
6.0	4.4	9	55	5.2	3.6	1.34	9.51	63½	87½	55¾	7	3.80	6.0
5.9	5.0	10	23	5.4	4.8	2.00	7.17	45½	63½	38½	6	2.60	5.7
5.3	5.1	15	26	5.6	5.1	2.35	9.79	47½	61¾	39	5	2.40	5.1
3.9	3.4	16	38	4.0	3.4	2.01	9.33	56⅝	69¼	48⅝	6	4.00	7.1
5.2	4.7	5	9	5.0	4.9	0.88	3.75	26	36½	24½	7	1.75	6.5
6.5	6.1	9	18	6.9	6.3	1.47	6.97	38¼	58¼	32¾	5	2.36	6.2
6.5	6.9	12	−6	6.1	7.2	0.83	3.50	28	39⅝	23¾	8	1.76	6.3
1.8	1.7	4	34	2.0	1.6	0.67	4.41	19¾	28⅛	18⅞	4	1.56	7.9
4.6	4.5	10	10	4.7	4.7	0.62	2.89	20½	26⅜	18	7	1.32	6.4
5.1	4.4	11	19	4.5	4.2	0.74	3.81	23	27	17½	6	1.20	5.2
6.7	6.8	1	−6	6.4	6.8	0.46	4.62	26½	49⅞	22¼	6	1.20	4.5
7.6	9.1	10	−1	8.0	9.0	1.46	5.96	34	66½	31⅜	6	2.60	7.6
4.9	5.0	1	3	5.1	5.0	1.05	4.47	23½	34½	21⅞	5	1.50	6.4
5.0	5.9	12	5	5.3	5.6	1.67	8.24	59	71¾	45¾	7	2.80	4.7
7.8	7.6	11	9	8.0	8.1	1.01	4.42	39¼	53¼	34	9	0.80	2.0
9.3	7.4	8	18	8.6	7.9	0.33	3.48	19⅜	27¾	17⅞	6	1.32	6.8
2.6	3.6	15	−11	2.8	3.6	1.02	3.76	25	33¾	23½	7	1.80	7.2
1.4	0.4	12	51	1.2	0.9	0.40	1.18	10⅝	15½	9¼	9	0.80	7.5
3.3	3.6	2	−6	3.5	3.8	0.88	3.92	29⅛	36	25¾	7	2.20	7.6
1.7	1.4	8	70	2.1	1.3	0.36	2.43	12⅜	16	11⅛	5	0.48	3.9
7.8	12.6	4	−29	8.5	12.4	0.39	3.14	21⅜	38⅞	20⅜	7	1.08	5.1
21.0	26.5	32	36	21.5	20.9	0.64	3.15	24⅝	40½	21¼	6	0.60	2.4
5.0	5.1	12	−1	4.9	5.5	0.79	2.90	30¼	39	26½	10	1.10	3.6
12.2	11.5	6	16	12.3	11.2	1.05	3.97	50	58¼	41	13	2.00	4.0
8.0	8.0	13	11	8.1	8.2	0.61	3.29	36½	41⅝	28¼	11	1.00	2.7
11.7	14.9	1	−20	11.6	14.6	0.30	1.87	20⅜	23¼	17⅞	13	1.00	4.9
7.2	6.9	10	5	6.7	7.1	0.76	2.44	17½	31¾	17¼	7	1.60	9.1
9.0	8.8	14	15	8.8	8.8	0.39	2.76	43¼	50¼	36¾	16	2.28	5.3
4.2	2.9	9	72	4.4	2.8	0.82	3.04	25¾	26	11½	8	0.48	1.9
9.1	10.0	18	11	9.1	9.8	0.47	3.28	29	44¾	25¼	9	0.80	2.8
3.2	2.8	2	−2	3.2	3.3	0.48	2.87	15⅝	18¾	11¾	5	0.96	6.1
5.7	8.5	10	−27	6.3	8.4	0.40	1.40	23	33½	18⅛	16	0.56	2.4
6.9	8.8	38	15	7.3	8.8	—	1.21	14⅜	30¾	13⅛	12	0.24	1.7
2.9	3.5	29	115	2.9	1.8	0.76	3.07	37¾	43¾	19	12	1.00	2.6
4.3	3.4	18	121	4.8	2.6	0.20	2.13	17½	20¼	12½	8	0.80	4.6
13.1	14.8	16	7	13.7	14.8	0.60	2.76	43¾	58½	36¼	16	0.48	1.1
3.4	5.6	2	def	def	3.0	0.27	0.42	9½	12⅛	8⅜	23	0.40	4.2
5.5%	**5.6%**	**9%**	**7%**	**5.4%**	**5.5%**								
6.9%	**7.8%**	**11%**	**6%**	**7.0%**	**7.3%**								
5.7%	**5.8%**	**9%**	**7%**	**5.5%**	**5.6%**								

gain in third-quarter 1981. l Excludes $2.4 million charge in nine-months 1981. m Excludes $2 million gain in nine-months 1980. n Excludes $4.5 million gain in third-quarter 1981 and $800,000 gain in third-quarter 1980; nonoperating gain in nine-months 1981 totaled $5.3 million and in nine-months 1980, $2.2 million. o Excludes $900,000 nonrecurring gain in nine-months 1981. na = not applicable. def = deficit.

time sales increased an almost equal 10% to $24.7 billion from the third quarter last year. Thus, profit margins (earnings as a percentage of sales) stayed the same at a depressed 4.8%. This is a far cry from the 7.4% that the companies achieved in the first quarter of 1980 or even the 6.3% and 6.0% they made in the first and second quarters of 1981. The last good third quarter was in 1979 when the 40 chemical companies had an average profit margin of 6.1%.

Earnings in the third quarter this year were as good as they were because of some large gains among the bigger chemical companies. For instance, Du Pont, even without including the results of the Conoco acquisition for the two months—August and September—that they were merged, had an earnings increase of 91%. Monsanto's earnings were up 89% from a year ago, B. F. Goodrich increased 57%, and Celanese had an increase of 55%. The biggest gain was at Stauffer Chemical, where earnings increased 218% in the third quarter from the same period of 1980.

These gains more than offset the

Earnings begin to drop at some chemical-producing oil companies

		THIRD-QUARTER 1981						NINE-MONTHS 1981		
	% chemical sales	Sales	Earnings	Change from 1980		Profit margin[a]		Sales	Earnings	Change from 1980
		($ millions)		Sales	Earnings	1981	1980	($ millions)		Sales
Exxon	7%	$27,614.0	$1075.0	3%	−21%	3.9%	5.1%	$85,406.0	$4500.0	6%
Mobil[b]	3	16,845.0	506.0	8	−30	3.0	4.6	50,549.0	1846.0	9
Texaco[b]	3	14,472.8	589.7	15	−7	4.1	5.0	44,731.9	1803.4	16
Standard Oil of California	3	11,458.0	527.0	10	−16	4.6	5.9	34,425.0	1809.0	9
Standard Oil (Ind.)[b]	9	7,956.7	528.3	23	18	6.6	6.9	23,949.0	1457.8	19
Gulf Oil[b]	10	7,430.0	316.0	12	30	4.3	3.7	22,504.0	930.0	6
Atlantic Richfield[b]	8	6,967.6	433.5	24	58	6.2	4.9	21,068.0	1201.5	26
Shell Oil	16	5,578.0	471.0	9	33	8.4	6.9	16,545.0	1242.0	12
Phillips Petroleum	14	3,900.0	192.3	21	−32	4.9	8.8	12,200.0	692.8	24
Occidental Petroleum[c]	16	3,730.7	115.8	26	−13	3.1	4.5	10,238.2	456.4	10
Sun Co.[b]	3	3,700.0	210.0	23	8	5.7	6.5	11,600.0	493.0	27
Tenneco	12	3,585.0	156.0	17	−4	4.4	5.3	11,170.0	553.0	17
Getty Oil	2	3,267.6	205.2	28	7	6.3	7.5	9,778.7	640.4	31
Standard Oil (Ohio)	4	3,010.8	470.0	18	8	15.6	17.0	9,038.0	1470.0	12
Union Oil[b]	10	2,872.0	168.6	9	38	5.9	4.6	8,314.0	531.0	7
Cities Service	7	2,144.7	77.6	28	−16	3.6	5.5	6,709.0	225.8	17
El Paso	14	1,061.0	39.2	21	54	3.7	2.9	3,069.0	107.8	17
Kerr-McGee	14	946.8	50.3	6	49	5.3	3.8	2,753.7	145.1	9
Internorth	12	741.6	28.3	26	93	3.8	2.5	2,622.2	185.2	23
American Petrofina	15	601.5	21.7	29	−24	3.6	6.1	1,981.7	57.2	33

a After-tax income as percentage of sales. b Excludes major nonrecurring earnings: Mobil—$459 million in first-quarter 1980; Texaco—$402 million in first-quarter 1980; Standard Oil (Ind.)—$80 million in third-quarter 1981; Gulf Oil—$100 million in first nine months 1980; Atlantic Richfield—$115 million in third-quarter 1980; Sun Co.—$135 million in second-quarter 1981; Union Oil—$24.4 million in second-quarter 1981. c Includes major nonrecurring earnings.

Petrochemical earnings still trail the pack

The largest part of the commercial chemical world outside basic chemical companies continues to show a fitful profits recovery. Like their basic chemical cousins, the petrochemical parts of oil and natural gas companies have reported a great range in year-to-year comparisons for the third quarter. Some improved considerably, but others slumped even more. Overall, petrochemical earnings held to their traditional lagging, magnified version of the overall chemical earnings pace.

For five major U.S. oil companies supplying after-tax data (Conoco having departed from the group to join Du Pont), petrochemical earnings slipped 2% in the third quarter from a year ago. That's better than the 18% drop in the second quarter and 55% sag in the first. But it's nothing to cheer about, since third-quarter 1980 was poor enough to offer an easy chance for improvement.

So for the first nine months of 1981, petrochemical earnings are still down 27% from the same period in 1980.

Some rays of hope light up a few corners in oil and gas companies' reports on the third quarter for petrochemicals, but not many. Although the largest petrochemical producer, Exxon, managed to increase earnings from a year ago, chairman Clifton C. Garvin Jr. treats the turnaround very coolly: "Chemical earnings showed a marginal improvement over the very depressed third quarter last year." For the nine-months results, still down from 1980, Garvin explains that physical sales volumes declined 3% worldwide. Profit margins abroad were squeezed by excess plant capacity and rising costs, particularly in Europe.

	AFTER-TAX EARNINGS					
	Third quarter			Nine months		
$ Millions	1981	1980	% change	1981	1980	% change
Exxon	$65.0	$58.0	12%	$222.0	$327.9	−32%
Mobil	17.0	21.0	−19	70.0	83.0	−16
Shell Oil	14.0	33.0	−58	35.0	110.0	−68
Standard Oil (Ind.)	19.3	10.5	84	110.4	115.8	−5
Texaco	12.9	8.4	53	61.6	47.6	29
TOTAL	$128.2	$130.9	−2%	$499.0	$684.3	−27%

Mobil also pointed to troubled European profit margins for both petrochemicals and plastics. Mobil adds that its U.S. petrochemical profit margins also fell from last year. As a result, the company had even lower profits this year than last in both the third quarter and first nine months.

Worst off among the group of five was Shell Oil with a third-quarter profits drop of 58%. President John F. Bookout Jr. says, "Higher sales volumes and prices generally offset increased variable costs, but were not sufficient to cover higher fixed costs associated with the startup and underutilization of facilities."

Standard Oil (Ind.) had higher chemical earnings in the third quarter than a year ago but chooses to look at the dark side in its commentary. Chairman John E. Swearingen says that, over the first nine months, although price increases generally have kept pace with raw material cost increases (the main variable type of cost), demand in several product lines has weakened.

NINE-MONTHS 1981			STOCK MARKET DATA							
Change from 1980	Profit margin[a]		Earnings per share		Stock price			Price-earnings ratio Oct. 30	Annual indicated dividend	Dividend yield, % of price
						Recent 12 months				
Earnings	1981	1980	3rd qtr	Recent 12 months	Oct. 30	High	Low			
4%	5.3%	5.4%	$1.25	$6.77	$\$30\frac{3}{8}$	$\$44\frac{3}{8}$	$\$29\frac{1}{2}$	4	$3.00	9.9%
−18	3.7	4.9	1.19	5.67	26	$44\frac{1}{4}$	$24\frac{1}{8}$	5	2.00	7.7
4	4.0	4.5	2.25	8.65	$32\frac{1}{2}$	$54\frac{3}{8}$	$31\frac{1}{2}$	4	3.00	9.2
1	5.3	5.7	1.54	7.09	$42\frac{3}{4}$	$51\frac{3}{4}$	$35\frac{1}{8}$	6	2.40	5.6
−4	6.1	7.5	1.81	6.38	$50\frac{1}{2}$	$99\frac{1}{2}$	$47\frac{1}{4}$	8	2.60	5.1
−7	4.1	4.7	1.63	6.33	$35\frac{7}{8}$	$52\frac{3}{4}$	$30\frac{5}{8}$	6	2.80	7.8
6	5.7	6.8	1.73	6.40	$48\frac{1}{8}$	$74\frac{3}{8}$	$38\frac{1}{4}$	8	2.20	4.6
10	7.5	7.6	1.52	5.34	$43\frac{3}{4}$	$65\frac{1}{2}$	$38\frac{1}{4}$	8	1.80	4.1
−11	5.7	8.0	1.86	6.44	$41\frac{1}{4}$	$62\frac{7}{8}$	$34\frac{1}{4}$	6	2.20	5.3
−20	4.5	6.2	1.13	6.57	$24\frac{3}{4}$	$39\frac{1}{8}$	$21\frac{5}{8}$	4	2.50	10.1
−29	4.3	7.6	1.68	4.64	$39\frac{1}{4}$	$59\frac{5}{8}$	29	8	2.10	5.4
5	5.0	5.5	1.09	5.66	$31\frac{3}{8}$	$58\frac{3}{8}$	$30\frac{3}{4}$	6	2.60	8.3
−3	6.6	8.9	2.50	10.36	$63\frac{1}{4}$	$108\frac{1}{4}$	$55\frac{1}{4}$	6	2.40	3.8
10	16.3	16.6	1.92	7.91	$43\frac{3}{8}$	$91\frac{1}{2}$	$36\frac{1}{8}$	5	2.40	5.5
13	6.4	6.1	0.66	4.08	$40\frac{1}{8}$	$56\frac{1}{2}$	$28\frac{1}{4}$	10	1.00	2.5
−39	3.4	6.5	0.94	4.01	$48\frac{3}{4}$	$69\frac{1}{8}$	$35\frac{1}{4}$	12	1.60	3.3
38	3.5	3.0	0.82	2.90	25	$29\frac{1}{2}$	$19\frac{1}{4}$	9	1.48	5.9
11	5.3	5.2	1.94	7.58	$74\frac{1}{2}$	93	$61\frac{1}{2}$	10	2.00	2.7
9	7.1	7.9	0.63	5.07	$28\frac{1}{4}$	$49\frac{3}{4}$	$27\frac{1}{2}$	6	2.12	7.5
−33	2.9	5.7	2.01	7.10	$56\frac{1}{8}$	$71\frac{7}{8}$	41	8	3.20	5.7

drops among the big companies of 32% at Dow, 10% at Union Carbide, and 45% at Williams Cos.

Among the 20 smaller companies on the list, there were no really big gains, except for a 98% increase at H. B. Fuller. However, there were some huge drops such as the 99% decrease at First Mississippi that all but wiped out earnings for the quarter.

As a result, in terms of average earnings gain, the 20 largest companies by far outperformed the smaller, more specialty-oriented companies on the list. At the 20 largest companies, total earnings were $1.03 billion, a 13% increase from earnings in the third quarter last year.

At the same time earnings were falling at the 20 smaller companies. For this group, earnings in the third quarter were $166 million, down 4% from the third quarter of 1980.

Sales at the larger companies and at the smaller increased almost the same in the third quarter. Sales for the 20 largest increased 10% to $22.2 billion from last year, whereas sales at the smaller companies went up 9% to $2.5 billion from third-quarter 1980.

As a result, the average profit margin for the group of larger companies rose slightly, whereas that at the group of smaller companies, though still higher than at the larger companies, fell dramatically. The average profit margin at the larger companies increased to 4.6% in the third quarter this year from 4.5% in the same period a year ago. At the 20 smaller firms, the average profit margin fell to 6.6% from 7.5% in the third quarter of 1980.

The first nine months, in many ways, resembles the third quarter. Earnings for the 40 companies increased 7% to $4.3 billion from the same nine months last year. Sales at the same time were increasing 10% to $76.5 billion. Profit margins for the companies, therefore, decreased slightly to an average of 5.7% from the 5.8% recorded in the first nine months last year.

As in the third quarter, earnings gains in the first three quarters were higher at the larger than at the smaller companies. Earnings at the 20 larger companies, again led by gains at a few big firms, increased 8% to about $3.79 billion from the year before.

At the smaller companies, earnings through the first three quarters declined 2% to $537 million from the first nine months of 1980.

Again, as in the third quarter, the sales increases for the two groups were within one percentage point of each other, but this time the smaller firms are on top. Sales for the 20 larger companies averaged a 10% increase to about $68.7 billion from the first nine months last year. The average increase for the group of smaller companies was 11% to a total of $7.75 billion from last year.

But, unlike the third quarter, profit margins in the nine months declined for both groups. The average profit margin for the 20 bigger firms declined to 5.5% in the first nine months of this year from 5.6% in the same period a year ago. At the group of smaller companies, profitability remained higher than that for the larger group, but still dropped to 6.9% from 7.8% in the first nine months last year.

Outside the 40 companies in the basic C&EN survey, third-quarter chemical results covered a dizzy range, from dramatically improved to considerably worse off. At most of these diversified producers, however, chemicals were not much involved in overall financial gains.

There were exceptions of course. For example, FMC, Vulcan Materials, Engelhard, NL Industries, and Kaiser Aluminum credit chemi-

Earnings tumble at many diversified chemical producers

		THIRD-QUARTER 1981						NINE-MONTHS 1981		
	% chemical sales	Sales	Earnings	Change from 1980		Profit margin[a]		Sales[a]	Earnings	Change from 1980 Sales
		($ millions)		Sales	Earnings	1981	1980	($ millions)		
General Electric	4%	$6640.0	$405.0	11%	13%	6.1%	6.0%	$19,680.0	$1200.0	9%
U.S. Steel[b]	12	3465.8	187.8	26	377	5.4	1.4	10,657.2	570.8	17
Dart & Kraft[c]	11	2565.4	80.5	7	−4	3.1	3.5	7,575.7	293.1	9
Eastman Kodak	23	2542.1	334.0	8	6	13.1	13.4	7,264.8	867.6	10
Goodyear Tire & Rubber	12	2312.2	38.2	8	−34	1.7	2.7	6,901.8	149.5	11
3M	15	1684.0	124.4	8	−31	7.4	11.5	4,930.0	402.1	8
Georgia-Pacific	13	1401.0	31.0	10	−58	2.2	5.8	4,192.0	138.0	13
Aluminum Co. of America[b]	10	1284.3	71.8	2	−4	5.6	5.9	3,888.0	254.4	1
Borden	34	1090.3	45.2	−5	4	4.2	3.8	3,351.8	117.5	−4
Northwest Industries[c]	4	977.8	72.4	38	88	7.4	5.4	2,714.7	191.1	32
Esmark	26	884.2	36.8	13	91	4.2	2.5	2,466.1	100.4	16
FMC	35	843.9	31.3	10	45	3.7	2.8	2,492.5	107.4	5
Martin Marietta	10	835.9	60.6	20	18	7.3	7.4	2,438.6	161.4	28
Pfizer	14	819.1	58.3	8	−13	7.1	8.9	2,427.2	197.8	10
Kaiser Aluminum	13	780.0	12.3	−5	−75	1.6	5.9	2,508.0	148.9	−5
NL Industries	26	715.1	85.4	38	102	11.9	8.2	2,008.0	220.4	31
Merck	16	699.5	85.9	1	−21	12.3	15.7	2,169.1	306.2	7
Borg-Warner	24	681.8	42.7	10	104	6.3	3.4	2,070.1	119.3	5
General Tire[b]	19	652.9	31.1	24	138	4.8	2.5	1,879.6	49.1	20
Eli Lilly	20	623.8	79.0	4	5	12.7	12.5	2,061.0	280.5	7
Koppers[c]	30	540.9	25.2	−3	10	4.7	4.1	1,505.1	37.6	6
Uniroyal[c]	27	533.8	8.4	1	500	1.6	0.3	1,701.7	38.7	0
Engelhard[b]	7	509.4	17.8	−32	2	3.5	2.3	1,647.7	53.5	−31
National Distillers[b]	36	480.1	29.6	6	63	6.2	4.0	1,511.0	98.4	0
Upjohn	19	447.7	31.2	3	−20	6.9	9.1	1,443.1	123.4	10
Emhart	16	401.6	19.8	−2	78	4.9	2.7	1,278.0	41.2	−3
Vulcan Materials	38	213.1	24.1	9	21	11.3	10.2	586.3	61.3	6
Big Three Industries	30	210.0	26.7	23	21	12.7	12.9	608.7	79.1	27
GAF	41	177.5	−5.1	−3	d	d	2.3	528.3	2.3	5
Ferro	15	171.6	2.9	−2	−68	1.7	5.2	540.0	12.5	5

a After-tax earnings as percentage of sales. b Excludes major nonrecurring earnings: U.S. Steel—$349 million in third-quarter 1981, $405 million in first nine months 1981, and $37.6 million in third-quarter 1980; Aluminum Co. of America—$9.5 million in third-quarter 1981 and $27.3 million in first nine months 1980; General Tire—$4.4 million charge in first-quarter 1981; Engelhard—$5.2 million in second-quarter 1981; National Distillers—$19.2 million charge in third-quarter 1980. c Includes nonrecurring earnings. d Deficit. na = not applicable.

cals with a major positive influence on overall corporate earnings. Special situations helped, such as FMC's reinvigorated pyrethroid insecticides, Vulcan Materials' fortunate position in booming caustic soda, NL Industries' improved titanium dioxide markets, and Engelhard's record-setting pace in cracking catalysts.

However, at several companies with vastly improved overall operations, chemicals have not joined the party. An extreme example is U.S. Steel, which surprised everyone this year by more than doubling its earnings, even without large nonrecurring gains, through the first nine months. Chairman David M. Roderick says, "All segments were profitable in the third quarter, although chemicals' results continued to be severely impacted by depressed market conditions." In other words, the company relied largely on its namesake product for recovery.

Another case is Esmark, whose appreciation on Wall Street has grown mightily this year on an 89% earnings gain through three quarters following a radical restructuring. Of its chemicals, Esmark says quietly that earnings decreased slightly in the third quarter while revenues increased 16%.

Then there's National Distillers, whose net income from continuing operations rose 63% in the third quarter from a year ago with no help from its important chemical line. Operating profits at its U.S.I. Chemicals subsidiary were down from 1980. Distillers chairman Drummond C. Bell comments that physical sales volume of major petrochemical products fell from recessionary 1980. These products include polyethylene, ethanol, and vinyl acetate. Increases in selling prices generally were not sufficient to offset cost increases. Another problem for U.S.I. is its joint syngas-fed complex with Du Pont outside Houston. Distillers say that it was not even in operation for a large part of the third quarter.

Overall, few chemical operations at diversified producers gave earnings any more of a push than chemicals gave basic companies in the third quarter. The result was a sluggish chemical quarter, even though parent company results ran over a huge spectrum. Year-to-year comparisons went from a 500% gain in profits at much-improved Uniroyal to a 75% collapse at Kaiser Aluminum.

For the whole 30-company group,

NINE-MONTHS 1981			STOCK MARKET DATA							
Change from 1980	Profit margin[a]		Earnings per share		Stock price			Price-earnings ratio Oct. 30	Annual indicated dividend	Dividend yield, % of price
						Recent 12 months				
Earnings	1981	1980	Oct. 30	Recent 12 months	Oct. 30	High	Low			
9%	6.1%	6.1%	$1.78	$7.07	54¼	69⅞	51⅛	8	$3.20	5.9%
106	5.4	3.1	1.98	8.25	28	35¼	21¼	3	2.00	7.1
3	3.9	4.1	1.48	7.16	48¾	52⅛	39¾	7	3.40	7.0
16	11.9	11.3	2.07	7.89	65½	85⅜	60⅝	8	3.00	4.6
−2	2.2	2.4	0.53	3.15	17⅞	20¼	15	6	1.30	7.3
−20	8.2	11.0	1.06	4.92	49⅝	65	48	10	3.00	6.0
−23	3.3	4.8	0.29	1.88	18½	32⅜	17¾	10	1.20	6.5
−25	6.5	8.8	0.95	4.73	24⅛	37½	22¾	5	1.80	7.5
3	3.5	3.3	1.47	4.91	28	30	23⅞	6	2.05	7.3
90	7.0	4.9	2.35	7.98	60½	61¾	32¾	8	2.68	4.4
89	4.1	2.5	1.80	5.67	52½	55½	24	9	1.84	3.5
5	4.3	4.3	0.87	4.10	25⅞	35¾	24	6	1.60	6.2
12	6.6	7.6	1.62	5.47	36⅝	51⅛	28⅜	7	1.92	5.2
4	8.2	8.6	0.78	3.51	45½	54⅞	40	13	1.60	3.5
−27	5.9	7.7	0.28	4.34	16¼	27½	15⅜	4	1.40	8.6
86	11.0	7.7	1.27	4.00	43¾	48⅝	30½	11	1.00	2.3
−5	14.1	15.9	1.16	5.38	79⅞	103	73⅛	15	2.60	3.3
35	5.8	4.5	2.00	7.30	48⅜	53⅞	37¼	7	2.80	5.8
975	2.6	0.3	1.28	3.31	25½	29½	17½	8	1.50	5.9
8	13.6	13.6	1.04	4.76	52¾	68¾	45¼	11	2.30	4.4
−12	2.5	3.0	0.84	1.57	18	33¾	17¼	11	1.40	7.8
d	2.3	d	0.27	1.49	8⅝	10⅜	4⅜	6	0	0
5	3.2	2.1	0.66	na	20⅞	30¾	17	na	0.56	2.7
37	6.5	4.8	0.85	3.99	23⅞	32⅞	22	6	2.20	9.2
−9	8.6	10.4	1.03	5.27	49	69	45⅝	9	2.00	4.1
−20	3.2	3.9	1.57	4.55	29⅝	37½	26⅛	7	2.40	8.1
24	10.5	8.9	2.08	7.08	49¾	56	39¾	7	2.20	4.4
26	13.0	13.1	0.63	2.44	27⅞	38	25	11	0.60	2.2
−81	0.4	2.4	−0.41	−0.22	14¼	16⅜	9¼	d	0.80	5.6
−40	2.3	4.1	0.37	2.68	27	31½	20	10	1.20	4.4

earnings went up at 19 and down at 11. Profit margins improved over recession-bound third-quarter 1980 for just 16. That indicates a substantial profit-margin problem still unsolved from last year for many companies.

For the 20 major chemical-producing oil and natural gas companies in C&EN's survey, corporate earnings have turned for the worse after surviving last year's recession in good shape. Most notably, earnings fell in the third quarter at all of the top four oil companies—Exxon, Mobil, Texaco, and Standard Oil of California. For all 20, earnings fell at nine and rose at 11. Profit margins fell for 13. For the moment, the bloom is off petroleum profits, although the exploration business continues at a furious pace, aiding earnings at big suppliers such as U.S. Steel, NL Industries, and Big Three Industries. U.S. Steel's role here comes through producing shortage-plagued drilling pipe.

For the balance of the year, chemical companies are generally none too confident. At American Cyanamid, chairman and chief executive officer James G. Affleck says that slack demand and dramatically lower prices for fertilizers plus the strengthening of the U.S. dollar against foreign currencies will continue to have an unfavorable impact for some months to come.

Alexander F. Giacco, chairman of Hercules, says, "We do see signs of weakening in most of our business areas as customers hesitate to build inventories. It would appear that the economy may well be flat over the next few months until the current uncertainties are resolved.

Ethyl chairman F. D. Gottwald Jr. states that "even with improved third-quarter net income, we still do not have confidence that the fourth-quarter results will be as good as last year's record fourth quarter."

And at Mallinckrodt, president Raymond F. Bentele says, "The company's performance was encouraging in the slow economy which characterized the third quarter. We anticipate that profits in the fourth quarter will continue to reflect increasing weakness in the domestic economy, a further softening of economies abroad, and a strong U.S. dollar." Bentele does think, in spite of this, that with a nine-month earnings gain of 12% safely under its belt, "Mallinckrodt's profits and sales for the full year of 1981 will exceed the 1980 results." □

Canadian chemicals continue in doldrums

Combined earnings for four largest companies in third quarter were lower than comparable period a year ago for fifth consecutive quarter

As third-quarter earnings figures come rolling in from Canadian chemical companies, it is becoming painfully obvious that the Canadian chemical industry is hurting.

Among the major publicly reporting companies, the results are disturbingly similar. C-I-L Inc. reports sales up during this year's third quarter compared to the third quarter of 1980. But earnings are down.

For Celanese Canada, the story is the same: sales up, earnings down. Union Carbide of Canada's sales are up, but earnings are way down. Only Du Pont Canada among the four major chemical companies was able to register increased earnings on increased sales, but that was only 1.4%.

A feel for how the industry as a whole is doing in Canada can be obtained by taking a look at the combined sales and earnings figures for these four companies. In this year's third quarter, combined sales for the four were up 14.5% over the third quarter of 1980 (although they were down 16.6% from the second quarter of this year).

The bite comes in net (after-tax) income. The four-company total for the third quarter of 1981 is down a hefty 35% from last year's similar period and a resounding 51% from this year's second quarter.

To make matters worse, this is the fifth consecutive quarter that the combined earnings of these four companies were lower than the earnings in the comparable period of the previous year.

Something, obviously, is wrong.

What's wrong is that Canadian chemical companies are caught in the classic cost-price squeeze. Raw-material costs are rising rapidly, particularly of oil and gas-based feedstocks that have been affected by Canada's national energy policies.

Meanwhile, a stagnant economy at home and stiff competition in the industry's all important export markets have put an effective lid on prices. Surplus capacity and rising labor costs haven't helped any.

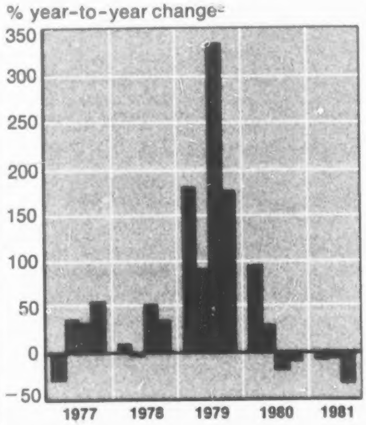
The inevitable result: lower profits despite increased sales.

The results of Union Carbide of Canada are fairly typical. In this year's third quarter, it recorded a 10.9% increase in sales, but suffered a 63% drop in net income.

Company chairman John S. Dewar says that the company did better in the gases, metals, and carbon segments of its business. The major earnings shortfall came in chemicals and plastics. Dewar notes that in Canada the cost of ethylene, which is the company's largest single cost factor in petrochemical production, escalated almost one third this year, primarily as a result of government policies. Meanwhile, he says, ethylene costs remained relatively stable in the U.S. and dropped in Europe and Japan.

Carbide's export sales rose 33% during the first nine months of 1981, but domestic shipments chalked up only a 7% gain. For these nine months, Carbide's net income is down 45%. The basic reason: Although sales volume is up 12%, prices have declined 2%.

Combined earnings plummet in third quarter



[a] After-tax earnings of four largest publicly reporting Canadian chemical companies—Celanese Canada, C-I-L, Du Pont of Canada, and Union Carbide of Canada.

Sales are up, but earnings suffer

	NINE-MONTHS 1981					
					Profit margin[a]	
$ Millions (Canadian)	Net sales	Change from 1980	Net income	Change from 1980	1981	1980
C-I-L Inc.	$ 882.3	18.9%	$ 45.1	10.0%	5.1%	5.5%
Celanese Canada	275.9	10.6	13.3	−5.7	4.8	4.9
Du Pont Canada	871.8	21.7	35.6	6.9	4.1	4.6
Union Carbide of Canada	622.9	9.8	33.5	−45.3	5.4	10.8
TOTAL	$2652.9	16.6%	$127.5	−14.8%	4.8%	6.5%

[a] Net income as percentage of sales.

Third-quarter earnings of Celanese Canada were hit hard by a work stoppage at its Sorel carpet plant and the subsequent sale of the carpets division to St. Georges International. The carpets division had a net loss of $3.7 million during the third quarter of 1981, including what the company lost in selling the division. The division had been losing money for several years.

Du Pont, the only one of the four Canadian chemical majors to chalk up an increase in net income during the third quarter, owes that achievement to improved fibers sales. During the first nine months, in fact, earnings of the chemicals group improved only moderately while the plastics and films group reported sharply lower earnings. The reasons are weak markets, strong price competition, and rising raw material costs.

Du Pont president James E. Newall doesn't expect much improvement in demand for his company's products over the near term. That may well describe the outlook for the entire Canadian chemical industry.

Earl Anderson, New York

Shifts ahead for trade in ethylene derivatives

By 1990, the global trade pattern of ethylene derivatives will look much different from today's. Countries and geographic regions that are now net exporters will have shifted to being net importers, and vice versa.

This is the projection of Jan 'T. Quant, general manager of base chemicals at Shell International Chemical Co., in London. His views, encouraging to some, must be disquieting to others who heard his talk at last month's meeting of the European Petrochemical Association in Venice.

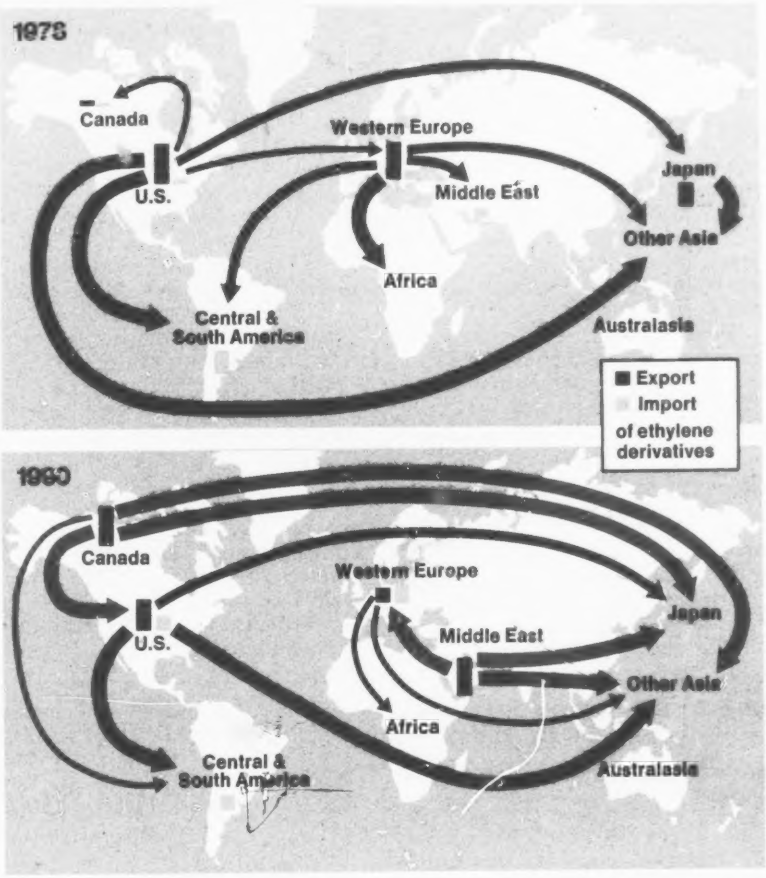
The reason for the shift will be the establishment of ethylene production in areas where there are plentiful supplies of natural gas at favorable prices. These are predominantly Canada and Middle East countries.

Japan might be most severely affected. From being a net exporter of some 700,000 metric tons of chemicals (in terms of ethylene content) in 1978, Quant foresees Japan being a net importer of 1 million metric tons in 1990. "Although all ethylene derivatives are to some extent affected by the emergence of new producers, it is low-density polyethylene, ethylene glycol, and possibly ethylene dichloride which exert the major influence in the trade patterns," Quant observes. For instance, Japan exported 300,000 metric tons of LDPE, and 200,000 metric tons of glycol (in terms of ethylene content) in 1978. By 1990, the situation will have been fully reversed.

Western Europe as a whole, too, will move into a net import position during this decade. In 1990, Quant expects the region to be a net importer of some 100,000 metric tons of LDPE (ethylene equivalent), in contrast to the 500,000 metric tons of net exports in 1978. For ethylene glycol, the anticipated 1990 net import volume will be 300,000 metric tons of ethylene content, against net exports of 100,000 metric tons in 1978.

The U.S. overall will remain a net exporter of ethylene-derived chemicals for the remainder of this decade. But Quant believes that the volume of these chemicals will be just about halved from 900,000 metric tons (ethylene equivalent) in 1978 to 500,000 metric tons in 1990. U.S. imports and exports of LDPE will be in balance in that year, compared to the 300,000-metric-ton (of ethylene equivalent) excess of exports over imports in 1978. Ethylene glycol will

Canada and the Middle East will emerge strongly as exporters of ethylene derivatives



Source: Shell

Olefins derivatives growth higher outside industrial countries

Millions of metric tons per year	Ethylene derivatives 1978	Ethylene derivatives 1990	Ethylene derivatives % annual change	Propylene derivatives 1978	Propylene derivatives 1990	Propylene derivatives % annual change
Western Europe						
Consumption	9.8	13.3	2.6%	5.3	7.6	3.0%
Net exports/(imports)	1.2	(0.1)		0.5	0.5	
Production	11.0	13.2	1.6	5.8	8.1	2.8
North America						
Consumption	11.6	16.3	2.9	5.9	8.8	3.4
Net exports/(imports)	0.9	1.6		0.3	0.6	
Production	12.5	17.9	3.0	6.2	9.4	3.5
Japan						
Consumption	3.7	6.5	4.8	2.1	3.2	3.6
Net exports/(imports)	0.7	(1.0)		0.4	0.1	
Production	4.4	5.5	1.9	2.5	3.3	2.4
Other noncommunist countries						
Consumption	4.5	10.9	7.6	1.6	4.3	8.6
Net exports/(imports)	(2.6)	(0.7)		(0.9)	(1.1)	
Production	1.9	10.2	15.0	0.7	3.2	13.5
TOTAL	29.8	46.8	3.8%	15.2	24.0	3.9%

Source: Shell

move from an export-import balance in 1978 to net imports amounting to some 100,000 metric tons of ethylene equivalent in 1990.

Quant makes the point that the new producers of ethylene and its derivatives won't affect propylene trade. The reason, of course, is that cracking of ethane doesn't result in anything like the amount of coproduct propylene that cracking naphtha or gas oil does. Western Europe and the U.S., and to a lesser extent Japan, will continue as net exporters of propylene chemicals to world markets, with 1990 levels about the same as they were in 1978.

"For existing ethylene plants around the world, there is unlikely to be a change in feedstock leading to a significant change in product mix," Quant believes. "The West European industry is based predominantly on naphtha and gas oil, with a limited ability to crack butane and propane. There does not appear any good reason except that naphtha and gas oil will not be available as before."

Turning to liquefied petroleum gas, Quant holds the view that "LPG will not become an attractively priced alternative feedstock for ethylene production except in a few special cases. The 10 million metric tons or so currently consumed annually in the petrochemical industry, mainly in the U.S., is unlikely to grow to any significant extent."

Of the nearly 30 cracker projects that various companies around the world have mentioned as having in mind, Quant believes that only eight will materialize between 1985 and 1990. All will be ethane-based. Combined, they will have an annual ethylene capacity of some 4 million metric tons. That will be less than 10% of the projected 47 million metric-ton ethylene demand throughout the noncommunist world by 1990.

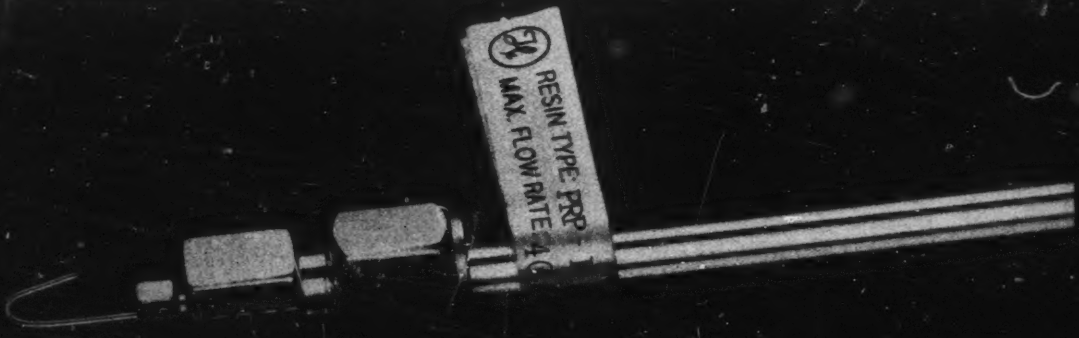
"Although in percentage terms this may seem relatively insignificant, its impact on product movements will be considerable," Quant warns. "For the European market for ethylene derivatives, Saudi Arabia will have a substantial cost advantage, even after transport costs are taken into account. In the Far East, Canada seems well set to displace Japanese and other producers from their traditional export markets." □

European petrochemical industry faces pitfalls

A number of pitfalls lie ahead of West European petrochemical investment strategies. "Prospects for the industry are poor unless some remedial action can be initiated in the near future," Shell's Anthony Lowe warned attendees at the European Chemical Market Research Association meeting in Cannes, France.

Lowe, who heads chemical planning and economics at Shell International Chemical Co. in London, outlined some of these pitfalls at about the time his colleague Jan Quant was addressing his audience in Venice (see previous story). He makes the point that "Europe in general, in its inability to arrive at a societal consensus, is fundamentally different from the U.S. and Japan.

"This difference, between Europe on the one hand and the U.S. and Japan on the other, is something which, in my view, the macroeconomists in their great forecasting institutions fail to take account of," he says. But although he detailed the



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HAMILTON SEPARATES

Chemical & Engineering NEWS

November 23, 1981

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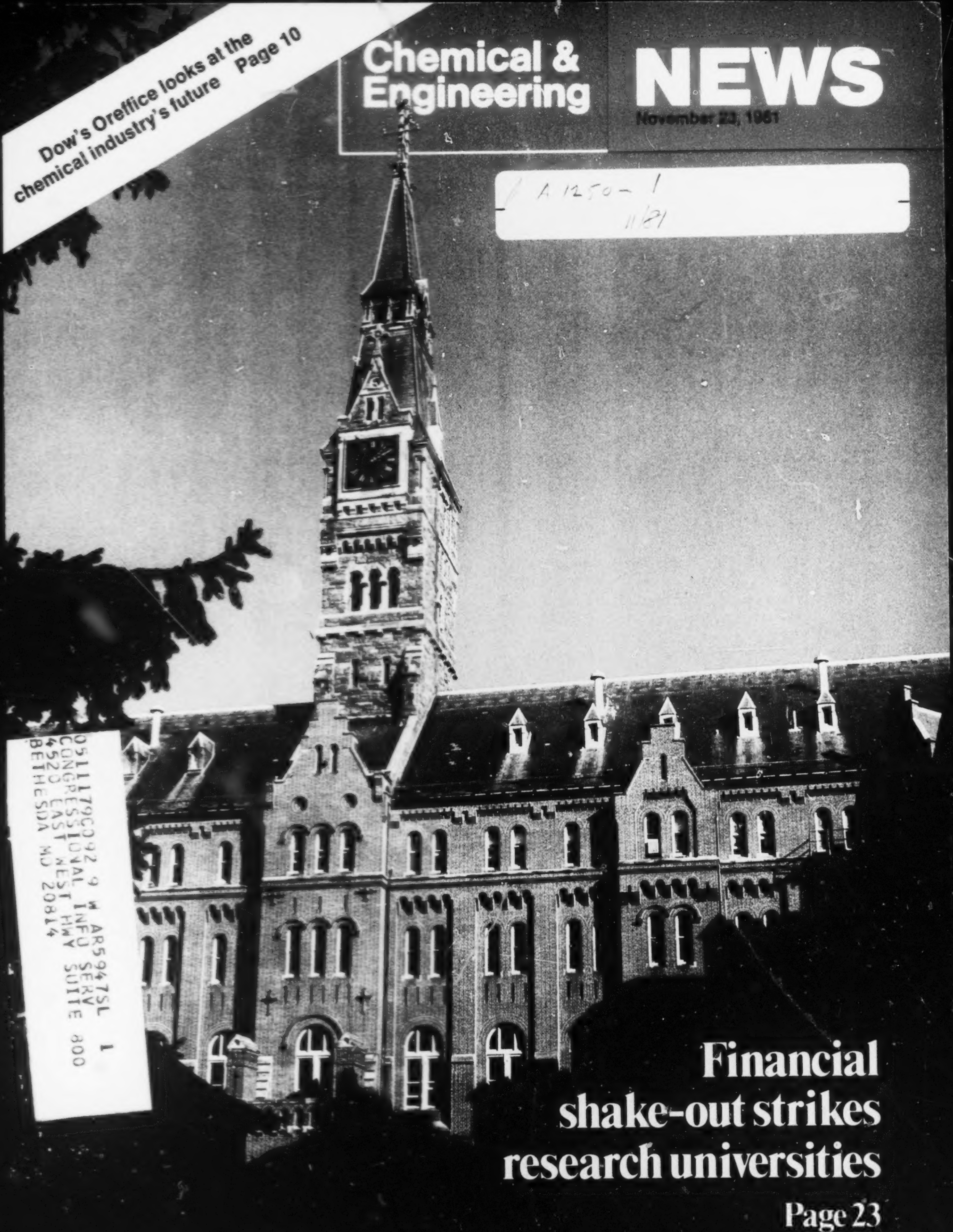
Dow's Oreffice looks at the chemical industry's future Page 10



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Financial shake-out strikes research universities

Page 23

November 23, 1981
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Chemical & Engineering NEWS

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2 Letters
3 Editor's Page

Concentrates
8 Business
14 Government
17 Science/Technology

The Departments
39 Awards
52 Newscripts

News of the Week

- ***Multifiber Arrangement negotiators*** *must find formula to satisfy both developing and industrialized countries.* ***Page 4***
- ***Fred Basolo,*** *Morrison Professor of Chemistry at Northwestern University, is 1982 ACS president-elect.* ***Page 5***
- ***Joel H. Hildebrand*** *celebrates 100th birthday with more than 1000 friends; receives first Berkeley Medal.* ***Page 5***
- ***Salaries of scientists and engineers*** *continue to rise but inflation drops purchasing power below earlier levels.* ***Page 6***
- ***House says no*** *to President Reagan's 12% budget cuts; rejects efforts to cut continuing resolution 5%.* ***Page 6***

Business

- ***Dow Chemical head Paul F. Oreffice*** *discusses the future of the company and the chemical industry.* ***Page 10***

Government

- ***Prospects for immediate decontrol of natural gas*** *are poor in face of uncertain effects on inflation and unemployment.* ***Page 15***

Science

- ***Differences in drug metabolism rates*** *in children and the elderly becoming more and more evident from a variety of pharmacological studies.* ***Page 18***
- ***Mutagenic effects on humans*** *of chemicals used in agriculture are difficult to determine despite a variety of tests available for use on animals.* ***Page 19***
- ***Main group chemistry workshop,*** *funded by the National Science Foundation, aims to stimulate interest in and upgrade quality of research in that area.* ***Page 21***
- ***Mathematical model*** *to predict the number of engineering degrees to be awarded in U.S. schools during the next 10 years to be set up by AAES.* ***Page 21***

Education

- ***Research universities,*** *faced with new technologies and declining federal funds, are being forced to rethink their relationship with industry and government.* ***Page 23***

Books

- ***"Dealing with Risk,"*** *edited by Richard F. Griffiths, presents seven essays by British authors on appraising and managing today's technological hazards.* ***Page 33***

ACS News

- ***Compliance rate*** *with ACS Professional Employment Guidelines remains at the 43% level following latest CPR report of industry layoffs of chemists.* ***Page 36***
- ***Woman chemists*** *are more likely to compromise their careers for marriage and family than are men, survey shows.* ***Page 37***

COMPLEX TEXTILE TRADE TALKS BOGGED DOWN

Opening salvos were sounded last week at the final session of the Multifiber Arrangement (MFA) renegotiations in Geneva. Their reverberations will be felt around the world wherever fibers, textiles, and apparel industries are key components of local and international commerce.

The existing MFA terminates Dec. 31. Delegates and observers from some 60 countries, meeting at the General Agreement on Tariffs & Trade (GATT) headquarters, will have their work cut out for them to arrive at an acceptable formula in time for a new MFA to come into effect Jan. 1.

MFA, or the Arrangement Regarding International Trade in Textiles, to give its full title, operates under the auspices of GATT. It establishes the groundrules for bilateral arrangements that set quotas in textiles and garments between more than 40 producing and importing countries.

MFA's original objective was to "achieve. . .progressive liberalization of world trade in textile products." But it has since become an instrument of protection used by the developed industrialized countries to stem the rise of imports of relatively low-cost goods from many of the less-developed countries. Some of these, notably Hong Kong, South Korea, and Taiwan, have emerged as significant suppliers of textiles and clothing on world markets.

Negotiations toward MFA renewal have been in progress for the best part of a year. Strands of the debate are many and complex and closely interwoven.

Broadly, developing countries, ranging from Bangladesh to Taiwan, seek greater access to the large markets of the European Economic Community, the U.S., and elsewhere. Industrialized countries are striving to maintain jobs and local business in the face of increasing outside competition.

Textiles, clothing imports up most in Western Europe

Millions of lb	EEC[a]	Japan	U.S.
1973	1.82	0.82	1.09
1974	2.39	0.76	0.93
1975	2.55	0.41	0.95
1976	3.19	0.50	1.29
1977	2.93	0.46	1.31
1978	3.14	0.76	1.57
1979	3.73	0.96	1.33
1980	3.83	0.82	1.43
% change, 1973 to 1980	110%	0%	31%

a European Economic Community. **Sources:** Commission of the European Communities, Japanese Ministry of Finance, U.S. Department of Commerce

In addition, makers of man-made and natural fibers, and of auxiliary chemicals such as dyestuffs and finishing agents have a stake in the outcome of the discussions. Meanwhile, consumer groups are arguing that protectionism serves to keep retail prices higher than they might otherwise be.

The 10 EEC countries, which have a single collective voice at the Geneva talks, have been embroiled in an intensive debate as to what demands to bring to the negotiating table. Denmark, West Germany, and the Netherlands, who have been favoring a more liberal approach, seemingly have lost out to those seeking a hard-line attitude—France and the U.K., with the support of the others. Discussions in Brussels extended into the early hours of the morning last Wednesday. But Horst-Günter Krenzler, head of the EEC delegation, was able to show up at the opening session of the Geneva discussions later the same day claiming that a mandate had been arrived at. The fact that the EEC now has an agreed position makes it possible for it to join fully in the negotiations.

The precise nature of the mandate was unclear at press time. But it is widely expected that one target the EEC hopes to achieve is to limit the annual growth in import quotas to around 1% in contrast to the theoretical 6%-per-year increase embodied in the current agreement. Preferential consideration might be given to those developing countries at the lower end of the scale of textile and garment producers, whereas cuts might be levied on the dominant suppliers like Hong Kong and Taiwan. And the level of imports into the EEC in 1980, a depressed year, might be used as a base on which to calculate future growth rates.

If the gulf between the developing-country delegates in Geneva, who seek a liberalization of import quotas, and the approach the EEC presumably will adopt isn't narrowed, it doesn't seem likely that the Dec. 18 deadline for reaching an agreement can be met.

On the other hand, there are those who share the view of Peter Murphy, the chief U.S. negotiator, that terms of MFA-3 should be set now, rather than continue deliberations into next year.

"The MFA [isn't] a perfect instrument," Murphy admits, "but it has worked reasonably well. We believe a continuation of that instrument offers the best approach available for the governments concerned to continue to manage trade in textiles and apparel in a reasonable manner. Our clear preference would be to change the MFA as little as possible."

A proposed draft protocol extending the MFA for a five-year term, instead of the present four years, that Murphy presented in Geneva last September, is widely considered as a document that provides a basis for fruitful discussion. It contains elements that should accommodate the concerns both of the EEC and of the developing countries. ☐

Net trade balance worse in U.S., most European countries

	Textiles		Clothing		Total	
$ Billions	1980	1973	1980	1973	1980	1973
EEC[a]	$ 0.78	$ 1.97	$−6.12	$−0.89	$−5.34	$1.08
France	−0.69	0.29	−0.33	0.45	−1.02	0.74
West Germany	−0.56	0.30	−5.46	−1.63	−6.02	−1.33
Italy	1.50	0.62	3.83	1.11	5.33	1.73
U.K.	−0.44	0.19	−0.98	−0.38	−1.42	−0.19
U.S.	1.25	−0.36	−5.29	−1.88	−4.04	−2.24
Japan	3.45	1.32	−1.03	−0.20	2.42	1.12

a European Economic Community. **Source:** General Agreement on Tariffs & Trade

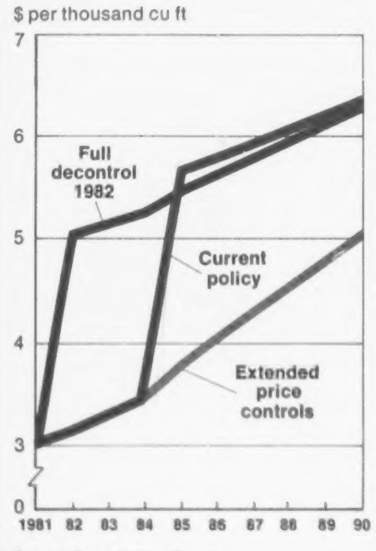
Immediate decontrol of natural gas unlikely

Faster decontrol of natural gas prices is politically unfeasible now because of controversy over its effects on inflation, unemployment

When President Reagan moved so quickly in January to remove all remaining price controls from crude oil, many thought it would not be long until the same action was proposed for the complex controls on natural gas. After months of speculation, however, a decision has been made to put off such action until sometime next year.

Decontrol of all gas prices has significant support, but the President probably is bowing to political realities. Sen. James A. McClure (R.-Idaho), chairman of the Senate Committee on Energy & Natural Resources, has said since January he does not want to take up gas decontrol until next year, and House minority leader Robert H. Michel (R.-Ill.) has said the House isn't going to consider decontrol before adjournment this year. Rep. John D. Dingell (D.-Mich.), chairman of the House Committee on Energy & Commerce, also opposes consideration of decontrol, adding that the 1978 gradual decontrol law is working well. In addition, Senate Republican leader Howard H. Baker Jr. (R.-Tenn.) has told the President that Congress will not agree to any speedup of gas deregulation unless there is some sort of windfall profits tax added as was done with oil deregulation.

Natural gas prices for industry will rise sharply



Source: Department of Energy

The focus of the debate is the National Gas Policy Act (NGPA) of 1978, hammered out after two years of struggle. But this law is considered badly flawed by many, and has not worked as planned. Under the law there are 20 categories of natural gas, including varieties of old interstate, old intrastate, new gas, and gas from certain wells deeper than 15,000 feet. Some of these are decontrolled now, some would be eligible for decontrol in 1985, and the rest, as much as 50%, would be under price controls indefinitely. The law, for instance, never decontrols "old" interstate gas, gas from old offshore leases, and new development wells under leases committed to interstate commerce as of 1977.

An analysis of NGPA and of the alternatives being considered by Congress recently has been released by the Department of Energy. It considers advantages and disadvantages of continuing with NGPA, extending price controls after 1985, and full decontrol of prices in 1982.

Unlike the relatively simple decontrol of crude oil, natural gas price controls are extremely complex. Involving three major business sectors—gas products, pipeline owners, and distributors—with low-cost, long-term contracts in the balance and hundreds of billions of dollars, the DOE report's assumptions have to be considered estimates at best. Still, the general conclusion is that natural gas prices in 1985 would be about the same if they were decontrolled next year or if the NGPA plans were followed for partial decontrol in 1985. Deciding to keep price controls after 1985 would hold prices down, the report finds, but at a high economic cost.

C&EN staff photo

Edwards: no significant impact

One of the principal complaints about the gas price controls as currently set up is that they give the wrong kind of incentives to the gas producers and gas consumers. The high prices allowed for the deep-well gas have encouraged exploration for this hard-to-get fuel, but easier-to-find gas goes begging because producers don't get so high a return for it. Consumers, on the other hand, are encouraged to use more and more gas because the low price, held down by NGPA, makes gas a cheaper fuel than fuel oil or electricity, discouraging conservation.

Proponents of natural gas decontrol believe all these problems would be solved if the gas were allowed to find its own prices in the open market. The DOE report argues that, aside from a very brief drop in employment and gross national product, total decontrol would increase efficiency of energy source use in the U.S., saving about $10 billion by 1985. It claims that accelerated decontrol would increase the supply of natural gas, resulting in more industrial use and a possible lowering of oil import levels. In all, demand would not rise—it eventually could drop—because prices would be higher, but supplies would rise as producers would be encouraged to find more gas. And Secretary of Energy James

Federal Alert—
new regulations

This listing covers noteworthy regulations appearing in the Federal Register *from Oct. 5 to Oct. 30. Page numbers refer to those issues.*

PROPOSED

Environmental Protection Agency—Reproposes, with revision, regulations for stack heights to control air pollution; comments by Nov. 3 (Oct. 7, page 49814).

Seeks comments for advanced proposal on toxicity testing of fluoroalkenes as recommended by Interagency Testing Committee; comments by Dec. 29 (Oct. 30, page 53704).

Transportation Department—Proposes Coast Guard rules to protect marine environment and safety for ocean thermal conversion facilities; comments by Nov. 23 (Oct. 5, page 49078).

FINAL

Drug Enforcement Agency—Lists chemical preparations and mixtures containing controlled substances exempted from provisions of Drug Abuse Prevention & Control Act; effective Dec. 28 (Oct. 29, page 53405).

Environmental Protection Agency—Redefines "source" under Clean Air Act as either entire plant or individual piece of equipment within plant; effective Oct. 14 (Oct. 14, page 50766).

Permits pesticides to be recommended for uses other than those specifically on label as long as restrictions are still met; effective Oct. 22 (Oct. 22, page 51745).

International Trade Administration—Removes all quantitative restrictions on export of refined petroleum products; effective Oct. 2 (Oct. 6, page 49108).

Transportation Department—Amends rules to ease shipment of fluorinated hydrocarbons and removes obsolete reporting requirements; effective July 1, 1982 (Oct. 8, page 49883).

NOTICES

Consumer Product Safety Commission—Extends until Feb. 15, 1982, deadline for making decision on banning urea-formaldehyde foam insulation (Oct. 6, page 49140).

Environmental Protection Agency—Announces availability of manual for maintaining security of business information under Toxic Substances Control Act (Oct. 8, page 49942).

Publishes agenda of new and existing regulations currently under consideration (Oct. 30, page 53900).

Nuclear Regulatory Commission—Requests comments on several options for storage and disposal of thorium and uranium wastes; comments by Dec. 22 (Oct. 23, page 52061).

Prices and quantities of natural gas under different options

	1982	1984	1985	1990
Natural gas supply[a]				
Current law (NGPA)	19.4	18.7	19.1	19.7
Extended controls	19.4	18.8	18,7	18.6
Full decontrol	19.7	19.4	19.3	19.2
Domestic wellhead prices[b]				
Current law (NGPA)	$2.27	$2.61	$4.45	$5.53
Extended controls	2.27	2.61	2.91	4.35
Full decontrol	4.19	4.44	4.65	5.50
Delivered residential prices[b]				
Current law (NGPA)	4.31	4.83	6.59	7.36
Extended controls	4.31	4.83	5.17	6.79
Full decontrol	6.13	6.39	6.62	7.51
Equivalent crude oil price[c]	5.74	6.08	6.27	7.27

a Trillion cu ft. b 1980 dollars per thousand cu ft. c 1980 dollars per thousand cu ft equivalents.
Source: Department of Energy

B. Edwards told the American Petroleum Institute recently that gas decontrol "would not have a significant impact on inflation or unemployment."

Not so, reply those groups opposing full decontrol. The initial spike of increases following decontrol would double prices, they say, creating economic chaos. Consumer groups have been very active in pointing out the possible problems of decontrol. The Energy Action Education Foundation contends decontrol would cost industry $158 billion over the next four years, with prices rising to $12.25 per thousand cu ft by 1985. The Citizen-Labor Coalition has predicted that decontrol could cause an increase of two to three points in the annual inflation rate and cost more than 3 million jobs.

Also not supporting decontrol are the gas distributors. The American Gas Association has decided to support current policies under NGPA. As a group representing the distributors that sell gas to residential and industrial users, AGA is concerned that they will not be able to pass large increases in costs on to users as the prices that distributors are allowed to charge are set by many state commissions.

As the largest industrial user of natural gas, the chemical industry has a healthy stake in the issue. It uses about 10% of all natural gas sold in the U.S., using 3% as feedstock for chemicals such as ammonia and fertilizer, and the other 7% for process fuel and other uses. Speaking for the chemical industry, the Chemical Manufacturers Association supports immediate full decontrol of gas. In a letter to Rep. Phil Gramm (D.-Tex.), who has introduced a bill to deregulate natural gas (H.R. 4390), CMA says the industry is willing to accept the increased costs of decontrol because "decontrol is necessary to remove artificial competitive inequities and to obtain greater assurance of adequate future supplies."

There are international issues to be resolved with natural gas decontrol as well. The U.S. imports quite a bit of gas from Canada and Mexico, at a price that is lower than the U.S. price would be if gas were decontrolled. Imports could be expected to rise, but prices also could fall on imported gas following full decontrol. This also would open the way for higher imports of gas-based methanol from Canada and Mexico, according to some analysts. Also, there is the possibility of increased gas imports from the Soviet Union.

Europeans probably would like to see natural gas decontrolled as well. This would remove, in their view, the unfair price advantage the U.S. has had for some products, especially textiles, over the past several years. Such a change could reduce U.S. exports.

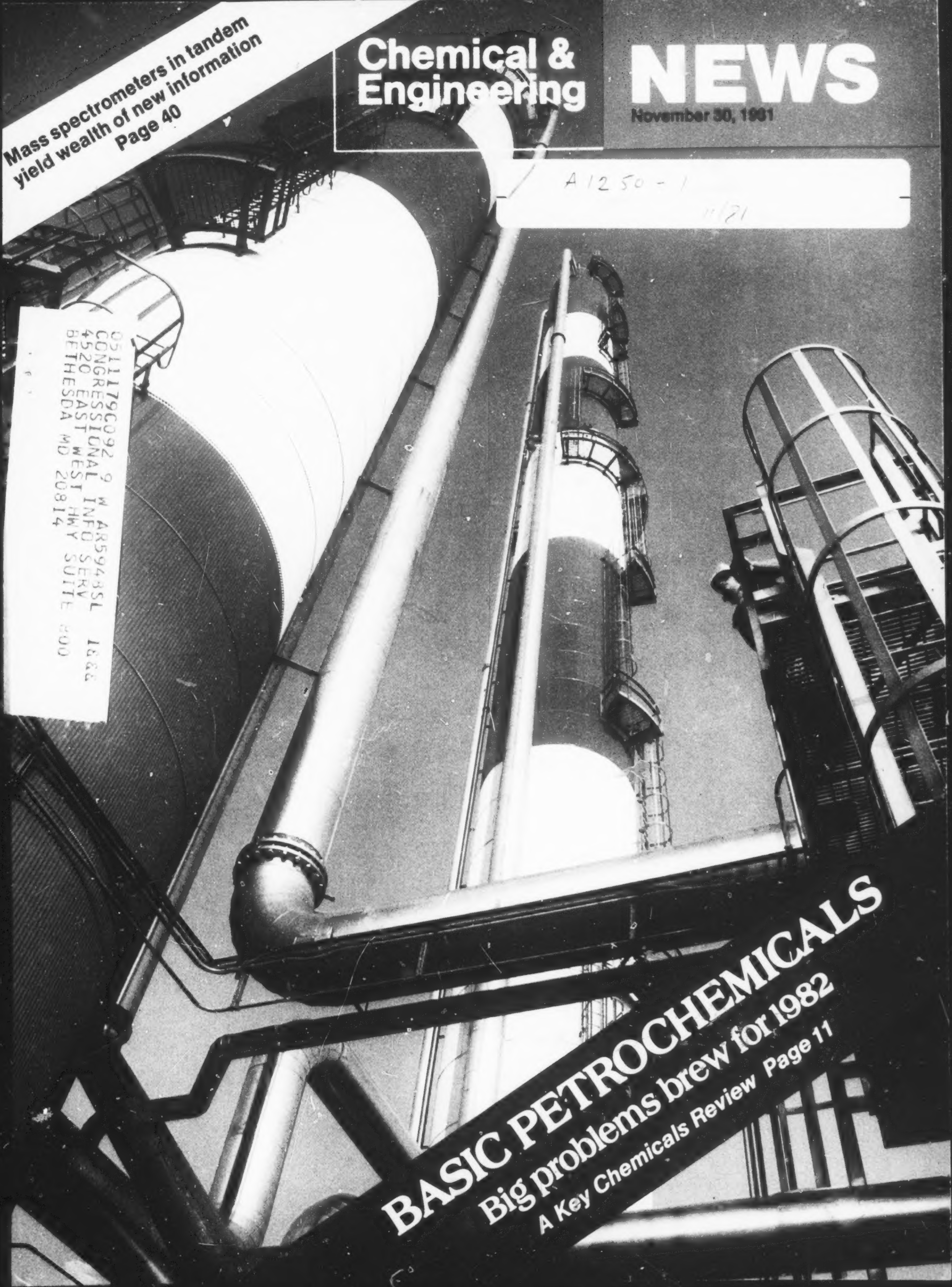
Whatever gains and losses would result from immediate gas decontrol, the chances that it will happen are getting smaller. Many Congressmen believe that the longer a strong effort on decontrol is put off, the less likely is passage of such a measure. If a bill is not passed by spring 1982, an election year, it will be difficult for lawmakers to decontrol gas in the summer and then to go back for re-election after having raised everyone's fuel costs. Most recent Administration plans described by Edwards call for accelerated decontrol to start in January 1983, with all price controls removed by Jan. 1, 1986.

David Hanson, Washington

Chemical & Engineering NEWS
November 30, 1981

A1250-1
11/21

Mass spectrometers in tandem yield wealth of new information
Page 40



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BASIC PETROCHEMICALS

Big problems brew for 1982

A Key Chemicals Review Page 11

November 30, 1981
Volume 59, Number 48
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ISSN 0009-2347

Chemical & Engineering NEWS

Cover: Propylene fractionation towers of Hercules' joint venture with Enterprise Petrochemicals Co. in Mont Belview, Tex.

4 Letters
5 Editor's Page

Concentrates
8 Business
20 Government
24 Science/Technology

The Departments
66 Newscripts

News of the Week

- ***EPA's implementation of superfund,*** *especially its ranking of hazards posed by waste sites, has been blasted by OTA.* ***Page 6***
- ***Clean Air Act has serious faults,*** *needs more than minor tinkering to assure clean air, a Brookings study finds.* ***Page 6***
- ***Some agency offices closed*** *and some worked on following President's budget veto and subsequent shutdown order.* ***Page 7***
- ***Solar energy system is being used*** *to generate process steam at Dow's Dalton, Ga., styrene-butadiene latex plant.* ***Page 7***

Business

- ***U.S. producers of basic petrochemicals,*** *troubled by falling output during the current business recession, face another no-growth year.* ***Page 11***

Government

- ***Budget chaos,*** *caused by Reagan's veto of the funding resolution, results in hard times for several research agencies.* ***Page 21***
- ***Keyworth advises science to set priorities,*** *evaluate areas of excellence and mediocrity, in talk to CSSP.* ***Page 23***

Science

- ***Fungal toxin in yellow rain*** *is being tested in the U.S. under the name anguidine as a potential cancer-fighting agent.* ***Page 29***

Education

- ***Shortage of engineering faculty members*** *attributed to declining number of doctoral candidates, lure of higher industry salaries, NSF survey reveals.* ***Page 30***

Technology

- ***Dynaphen process*** *produces phenol and benzene from coal liquids residue via thermal dealkylation.* ***Page 32***
- ***West Germany*** *has a myriad of projects under way, many in cooperation with other countries, to develop conversion processes for its extensive coal reserves.* ***Page 34***
- ***Coal conversion can become competitive*** *for petrochemical production in the 1980's, Lummus vice president predicts.* ***Page 37***

Special Report

Mass spectrometry/mass spectrometry *uses instruments in tandem to separate components in mixtures and perform sequence of operations on an ion beam.* ***Page 40***

ACS News

- ***Responsibilities of the chemical professional*** *was subject of conference held by ACS president Zettlemoyer.* ***Page 54***
- ***Society supports two new bills*** *on patent rights that would extend uniform government policy.* ***Page 55***

Basic petrochemicals still in trouble

With output falling in current business recession, basic olefins and aromatics face another year of low prices, profits, plant use

U.S. producers of basic petrochemicals are facing some of the most difficult times since the petrochemical industry first started in the early 1900's. The next few months probably will mark the low point of the current business trough. But after that, petrochemicals will take at least another year to regain their late-1970's volume.

That means three years of no growth from 1980 through 1982. Since plant capacity has moved up substantially, and petrochemicals' main cost load, in raw materials, has gotten much heavier, this bedrock product group is in very poor financial shape. For example, profits in leading oil companies' petrochemical operations in the third quarter were even worse than in last year's recession.

Unfortunately, some brand-new problems loom for petrochemicals over the next few years. One way or another, government-repressed prices for the olefins' most important raw material, natural gas, will be lifted. This will hand petrochemicals another huge increase in costs. If it happens too soon, petrochemical producers, caught in a surplus market, will have a rough selling job to talk customers into accepting higher prices. Customers may say no or turn to imports.

Imports, already increasing, could become a flood by the mid-1980's. Although much of these imports would come in the form of derivatives of the basic petrochemicals, the effect on U.S. petrochemicals would be the same—lost markets.

Imports could gain handsomely because the main wave of new petrochemicals production in the world will come from giant, efficient new plants built close to enormous foreign oil and natural gas fields. In other words, these plants will be making petrochemicals, especially olefins, by the simplest processes from the cheapest raw materials.

The only buffer for U.S. petrochemicals would be the foreign plants' relatively high capital cost and the transportation cost to markets. But these costs pale beside the dominant raw materials costs, which are naturally lower in western Canada, Mexico, and the Middle East.

The gush of new petrochemicals production in the world would be fine if world economies were bursting with growth. There would be room for everyone. But world economies at the moment are quite sick, and growth is at a standstill.

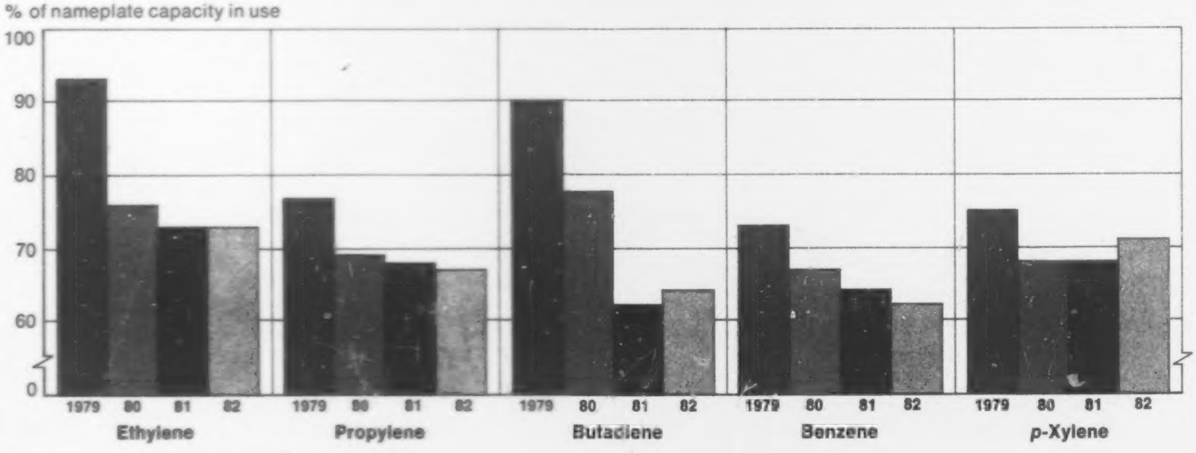
The drastic decline in market growth in the U.S. has undercut all the optimistic forecasts of the past few years for petrochemicals in the 1980's. The production outlook for the five major petrochemicals covered in the following pages—ethylene, propylene, butadiene, benzene, and *p*-xylene—is the same volume, 62 billion lb, in 1982 as in 1979.

But plant capacity for these five products jumped 21% from early 1979 to early 1982, to 93 billion lb per year. The yearly increases were 8% in both 1979 and 1980 and 4% this year. Meanwhile, production fell 9% in 1980, is rising 4% this year, and may rise 3% in 1982.

Growth in value for the five chemicals also has throttled down. The average weighted price for this group rose 29% in 1980 to 22 cents per lb from 17 cents in 1979. But the average price moved up only 9% in 1981 to 24 cents. Thus, total production value of these chemicals moved up 22% in 1980 to $13.2 billion but then rose just 13% in 1981 to $14.9 billion.

Bruce Greek, Houston, and
William Fallwell, Washington

Petrochemical plants still will run at very low levels in 1982



Sources: Industry, C&EN estimates, International Trade Commission

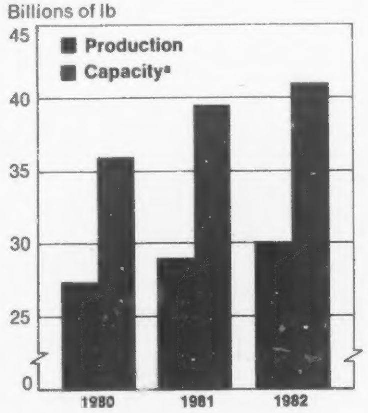
Key Chemicals

$CH_2{=}CH_2$

Ethylene

- ***Demand in slump***
- ***Capacity going up***
- ***Prices way down***

PRODUCTION/CAPACITY



[a] First quarter.

HOW MADE

Thermal (steam) and catalytic cracking of hydrocarbons ranging from natural gas-derived ethane to oil-derived gas oil (fuel oil)

MAJOR DERIVATIVES

Polyethylene 45%, ethylene oxide 15%, vinyl chloride 10%

MAJOR END USES

Fabricated plastics 65%, antifreeze 10%, fibers 5%, solvents 5%

FOREIGN TRADE

Negligible

PRICES

List price 25.5 cents a lb

COMMERCIAL VALUE

$7.0 billion for 1981 production

In the ethylene business, an irresistible force met an immovable object. Something had to give.

It wasn't the U.S. public, whose forceful letup in spending amid towering interest rates led to a new recession. It had to be ethylene producers, who have chopped prices to stay alive or given up and shut down plants.

These producers face an ever more difficult question: How low will prices go for the leading organic chemical and the largest-volume olefin? To many, the current list price of 25.5 cents per lb is below what they had thought was rock bottom. But to their dismay, further discounts of 8% are common. Larger discounts of 10% and more are widely rumored.

The basic problem is a classic case of too much plant capacity. To boot, much of this excess is the wrong kind, built to run on what looked like the only kind of feedstock available, high-priced gas oils and naphthas instead of traditional ethane and propane.

It's not hard to guess which kinds of plants have stopped running. More shutdowns may be the only solution for now, and the naphtha and gas oil crackers will be the ones to go.

Ethylene plants can be divided into these two broad types. About half or a little more, mostly older with lower capital investment, are fed very light liquids from natural gas, mainly ethane and propane. The rest run on heavier, oil-derived hydrocarbons of six or more carbon atoms—naphtha (like gasoline) and gas oil (like fuel oil).

This distinction has become a bit tricky. Due to modifications and experimenting, the boundary has blurred. Operators of ethylene plants designed for naphthas and gas oils are reducing their feedstock costs by substituting any light hydrocarbons they can get their hands on.

Currently, light liquids-based ethylene plants have a significant cost advantage over other ethylene plants. Ethane in particular has dropped in price as plant capacity has risen to take it out of natural gas. The exact cost advantage is difficult, if not impossible, to pin down.

But the advantage is very real. It has brought about shutdowns of varying amounts of capacity, nearly all steam crackers designed to use heavy hydrocarbons. The amount of ethylene capacity closed varies depending on factors such as feedstock availability, inventories of ethylene and its derivatives, and the sales outlook for these products. At mid-November, estimates of idled capacity ranged from 4 billion to 7 billion lb per year.

If November nameplate capacity is 41 billion lb per year, and shut-down capacity is about 5 billion lb, the remaining capacity would be running at an average rate of 75% or 27 billion lb per year. Industry analysts find telling evidence for such a low use rate in producers' bulging inventories. Inventories got this big because plants ran high last spring on optimistic sales forecasts for the second half of 1981.

The present slack is expected to hold ethylene production this year to about 29 billion lb, up 6% from 27.4 billion lb in 1980. However, industry projections range all the way from 28 billion or less to nearly 31 billion lb.

Part of the reason for this comparatively broad range comes from analysts' suspicion that some ethylene producers, with well over 1 billion lb of nameplate capacity, are not reporting monthly production. Unreported production, plus errors in reporting, could make the final 1981 production figure quite different from preliminary estimates.

Next year, the outlook for ethylene production depends entirely on the economy. Assuming a much improved second half, plus efforts to find new uses for ethylene derivatives, production of ethylene in 1982 could top 30 billion lb, but not by much. The current swollen inventory, equivalent to nearly two months' production, will have to be worked down during 1982's first half.

Behind the surge in inventories is an unexpectedly large decline in demand for ethylene derivatives, particularly polyvinyl chloride and polystyrene. The conventional polyethylenes have had their inventory problems too. Demand is shifting to the new-generation linear low-density polyethylenes.

The major ethylene derivatives all have lower long-term growth forecasts than in the past. Demand for derivatives is expected to pick up a little in 1982, but the ethylene business may never again be so lively as it once was.

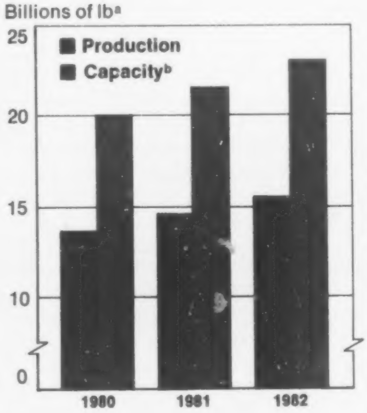
Key Chemicals

$CH_2{=}CH{-}CH_3$

Propylene

- ***Demand up a bit***
- ***Capacity rising***
- ***Prices holding***

PRODUCTION/CAPACITY



[a] Chemical and polymer grades. [b] First quarter.

HOW MADE

Recovered from cracked gas streams of olefins plants and oil refineries

MAJOR DERIVATIVES

Polypropylene 25%, acrylonitrile 15%, cumene 10%, isopropanol 10%, propylene oxide 10%

MAJOR END USES

Fabricated plastics 50%, fibers 15%

FOREIGN TRADE

Exports—negligible, imports—small, about 500 million lb in 1981

PRICES

Chemical grade 22 cents per lb; polymer grade 24 cents per lb; discounts small

COMMERCIAL VALUE

$3.25 billion for 1981 production

Comfort is very relative, and very scarce, in petrochemicals these days. The product closest to it in the current economic storm is propylene. Propylene's secret, oddly, is its complete lack of production independence. Although this may not sound too healthy, for the moment it means propylene is much better off than ethylene.

Propylene is in fairly good financial shape because its supply is held down by depressed production of coproduct ethylene, and its markets are stronger than ethylene's. The upshot is that propylene is not in a glut even in the current recession.

U.S. producers of propylene also find themselves in an unusual price position. Prices for much of polymer-grade (higher purity) propylene are almost as high as for ethylene, which usually rates several cents a pound more.

However, propylene output has to keep pace with ethylene. Forecasts for propylene production in 1981 call for an increase of about 7% to 14.7 billion lb from 1980. These estimates are for combined chemical and polymer grades. A further increase of 5% to about 15.5 billion lb is expected in the industry in 1982.

Demand for chemical- and polymer-grade propylene continues to be good compared to demand for other major organic chemicals. Since propylene supply is not much more than adequate, the market hasn't forced much discounting of propylene's price. Inventory building also has been relatively small compared to the bloated condition of ethylene. The snug fit of demand and supply for propylene could continue through most of 1982.

Fairly good demand is the rule through much of propylene's diverse line of derivatives. Derivatives exports appear to be holding up well this year, in contrast to declines in many other organics. U.S. demand for some derivatives has held up well, although it has fallen off for leading polypropylene in recent weeks. Until recently, technological innovations for polypropylene have kept demand at an even pace, if not up a bit.

Although demand has been very important in keeping up propylene's prices, supply factors are becoming even more important. If ethylene demand doesn't improve, some industry sources see a growing tightness in propylene supplies next year.

Propylene generally is the coproduct, not the primary product, in both its main sources—steam-cracking ethylene plants and oil refineries' catalytic crackers. A bit over half of both chemical- and polymer-grade propylene comes from steam cracking operations. For practical purposes, all of the propylene made in steam crackers becomes a chemical product. This contrasts with refinery propylene, of which part is never recovered and much goes to alkylation and other fuel uses outside chemicals.

Currently, both sources of propylene are operating well below practical capacity. The result is below-normal propylene supply. In the case of steam crackers, it isn't just low ethylene demand that has crimped propylene. Because the cost of raw material gas oil and naphtha is well above costs of alternative ethane and propane, operators of steam crackers have shifted to the lighter hydrocarbons as much as possible. Output of propylene from ethane and propane is meager compared to output from the heavier feedstocks.

Oil refineries have a large amount of propylene theoretically available from catalytic cracking operations. However, the cost of purifying this propylene, which often occurs in low concentrations, often can't be justified, especially to make the higher quality polymer-grade propylene. Hence, refinery capacity for each purification is well below the volume of crude propylene available.

Of course, for a price almost anything is possible. So things could change. For example, if propylene, especially polymer grade, becomes very tight, crude propylene streams from refineries could find their way to purification facilities of steam cracker units. Since many companies have both kinds of facilities close to each other, they easily could handle more propylene at not too much additional cost.

Hence, if demand for propylene derivatives continues relatively strong, then more refinery propylene will move into chemical and polymer uses during 1982. Producers will have to recover the additional costs involved. So prices are expected to firm even more in 1982.

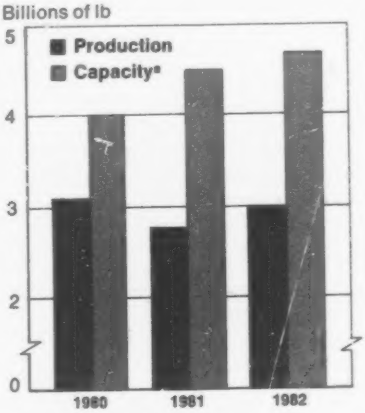
Key Chemicals

$CH_2{=}CH{-}CH{=}CH_2$

Butadiene

- ***Demand off***
- ***Capacity up***
- ***Prices holding***

PRODUCTION/CAPACITY



a First quarter; includes all sources.

HOW MADE

Recovered from steam cracker product streams; dehydrogenation of butylenes from oil refineries

MAJOR DERIVATIVES (U.S.)

Styrene-butadiene rubber 50%, polybutadiene rubber 20%

MAJOR END USES (U.S.)

Rubber products 80%, fibers 10%

FOREIGN TRADE

Exports—about 125 million lb, imports—off to about 350 million lb

PRICES

List price 42 cents a lb less 2 cents temporary cut

COMMERCIAL VALUE

$1.1 billion for 1981 production

Things are rarely what they seem for butadiene, the only big-volume commercial diene. Like propylene, it has two distinctly different sources in the U.S. But unlike propylene, butadiene also has a large, quirk-ridden foreign trade and a truly worldwide market. Add to this its chemical instability and single-market dependence on rubber. It's a business with plenty of suspense.

At the moment, this odd mix of forces gives U.S. butadiene much more firmness than its woebegone market suggests. One key is a big drop in imports because of a shift in world markets.

U.S. producers of butadiene have cut production this year but not so much as demand has fallen. The result will be output of about 2.8 billion lb, down 10% from 1980.

Despite the production drop, butadiene isn't faring that badly. Imports are expected down 40% or more to about 350 million lb this year. And production at both U.S. sources is actually close to its upper limit. Prices are considered relatively strong.

Behind butadiene's low volume is the wretched auto market. Rubber and tire production is easing further this fall as auto production drops and replacement tire sales dip. Tires and fabricated rubber products, a large part of which goes into autos, account for 80% of butadiene demand in the U.S.

Separately, coproduct butadiene output at olefins plants is falling because of these plants' low operating rates and feedstock switching. Much olefins capacity is shut down now. Production still running operates well below capacity, and the emphasis on cheaper light hydrocarbon feedstocks reduces proportionate output of butadiene.

The result is that the decline in U.S. butadiene production has all come out of these olefins plants. This situation will continue well into 1982, possibly throughout the year, unless a significant recovery from the current recession gets under way.

Butadiene's other U.S. source, independent dehydrogenation plants, is going almost full blast. These plants generally are operating at about their economic maximum, between 85 and 90% of nameplate capacity.

Most of the dehydrogenation plants and many of the multiproduct olefins plants either are owned by a producer of butadiene polymer or are closely associated with such producers. Hence, a lot of butadiene is funneled straight into polymerization by the same producer. Any additional butadiene then is purchased from outside olefins producers who may have no captive use for coproduct butadiene.

The remaining source of U.S. butadiene is imports, traditionally coming almost entirely from Western Europe. Europe's ethylene capacity long has been based totally on heavy feedstocks, which results in relatively large quantities of coproduct butadiene compared to the U.S. Surplus butadiene is generally the rule.

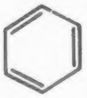
Around the globe, Japan's ethylene production, too, has been naphtha-based, but Japan's internal needs for butadiene usually have been so large that exports have been small. However, since Japan's ethylene plants now are running at reduced levels and demand for rubber there is still reasonably strong, Japan needs butadiene from Europe. So European butadiene producers have relatively less material to send to the U.S. That's just as well, under the circumstances.

The net result is that butadiene is one of the few major U.S. petrochemicals with reasonably strong prices. Depending on recessionary developments in the first and second quarters of 1982, prospects for butadiene prices are for no change or a slight firming. This is especially true if some additional olefins capacity is shut down. Of course, if U.S. auto production sags even more in the first half of 1982, butadiene demand will drop too, which could possibly weaken prices.

In 1981, actual demand, as opposed to production, for butadiene will total close to 3.1 billion lb. The major rubber uses, some three fourths of the total, will bear the brunt of the 500 million lb decline from 1980.

Customers' rebuilding inventories of finished rubber and downstream rubber products could help butadiene in 1982, but butadiene's U.S. capacity limitations may hold this down. At least, butadiene prices would avoid the sickly prospects that are confronting many other organic chemicals.

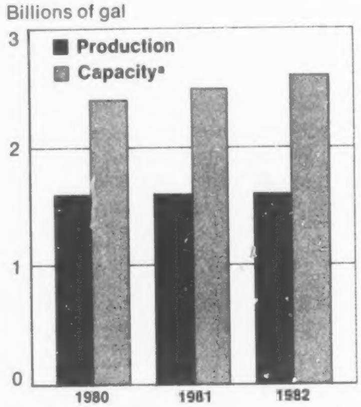
Key Chemicals



Benzene

- ***Demand flat***
- ***Capacity up a bit***
- ***Prices driven down***

PRODUCTION/CAPACITY



a First quarter; includes all sources.

HOW MADE

Separated from aromatics streams from oil refineries, steam-cracking olefins plants, coking of coal. Also via dealkylation of toluene

MAJOR DERIVATIVES (U.S.)

Ethylbenzene 50%, cumene 20%, cyclohexane 15%, aniline 5%

MAJOR END USES (U.S.)

Polystyrene 25%, phenolics 20%

FOREIGN TRADE

Exports—small, imports—rising to more than 100 million gal in 1981

PRICES

List price $1.55 per gal

COMMERCIAL VALUE

$2.4 billion for 1981 production

Like ethylene, benzene takes recessions broadside. It seems to have no protection from them. In theory, the leading aromatic is buffered slightly by some of the same supply constraints saving propylene and butadiene from gluts. In practice, however, benzene is too freely available, and its markets too weak, to ward off a crunch.

A crunch is exactly what has hit benzene over the past half-year. The best indicator is a 15% contract price drop since January. Alone among the top five petrochemicals, benzene will be worth less in 1981 than in 1980.

Benzene producers now are pulling through a slow fourth quarter. They fear that things wil not brighten in early 1982 either. All hopes of real improvement are delayed to 1983 at best.

Since the current quarter appears to be the slowest of the year, total benzene production in 1981 will do well to match that of 1980 at a bit less than 1.6 billion gal. Next year, because of an expected slow first half, production will again do well to reach 1.6 billion gal.

These estimates for 1981 and 1982 represent a consensus of industry sources. They differ from an official production total of 1.8 billion to 1.9 billion gal extrapolated from the latest 1981 data from the U.S. International Trade Commission.

The exact reason for the discrepancy is unknown. Some industry opinion is that the government figures are suspect. The reasoning goes that efforts of companies to reduce overhead costs have resulted in transfer of production reports from operating management to staff functions such as data analysis and government contact departments. Personnel in these departments are less familiar with operating procedures and hence are unable to detect inconsistencies in data. Poor or irrelevant data then go to ITC, leading to inaccurate official reports.

Plant capacity for benzene totals 2.6 billion gal a year and is rising slowly. There are four separate sources: catalytic reformate in oil refining, pyrolysis gasoline in olefins plants (significant if the feedstock is naphtha, gas oil, or a similar heavy hydrocarbon), dealkylation of toluene, and coal tar.

Each of these sources has special circumstances in its operation. As a result, production at a particular benzene plant can vary from all-out to nothing and sometimes not reflect the actual market pace.

At present, these special influences are very much at work. At refineries, the biggest source, weak gasoline demand is reducing pressure on aromatics production (for octane boosters) but not enough to block benzene for chemical use. Because of its sheer size, refinery benzene is the swing source. Benzene production for chemical use usually can move up or down with only a small impact on aromatics that go into gasoline.

Refinery benzene conditions largely determine how much extra benzene is produced by dealkylation of toluene. If benzene prices are weak, as at present, and raw material toluene not cheap enough, dealkylation units shut down. It doesn't take much time or money to close or reopen these units. So the dealkylation route is in and out of operation as the economic wind blows.

The third source of benzene, olefins plants, also is in a slump. Like coproduct propylene, coproduct benzene output is low because of plant shutdowns and substitution of light feedstocks for the heavies. Almost no benzene is produced when the feedstock is an ethane-propane mix. Only small amounts result from butane feedstock.

The final benzene source, coal tar, is small. It has been hurt by a decline in steel, which leads to lower demand for coal.

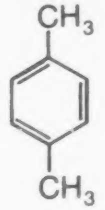
Overall, benzene production has been held down a bit in all of its sources. But markets have died down even more, and benzene is in clear surplus. Hence the deep price cuts.

Short-term prospects for improved demand for benzene by derivative makers are poor. Styrene, the major use of benzene through ethylbenzene intermediate, is expected to have little growth in demand in 1982 as in 1981. Styrene polymers, with styrene either alone or with other monomers, are headed for minor increases in 1982 or none at all.

Other benzene derivatives such as phenol and cyclohexane face equally bleak prospects because their main uses are in housing, an industry going steeply downhill.

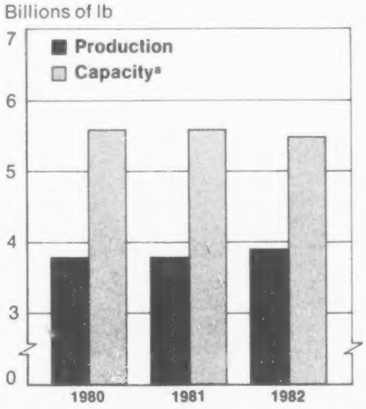
Key Chemicals

p-Xylene



- ***Demand flat***
- ***Capacity shaved***
- ***Prices level***

PRODUCTION/CAPACITY



a First quarter.

HOW MADE

Separated from mixed xylenes made in oil refineries or in steam-cracking olefins plants

MAJOR DERIVATIVES (U.S.)

Dimethyl terephthalate 55%, terephthalic acid 45%

MAJOR END USES (U.S.)

Polyester fiber, film, and fabricated items, mostly bottles, almost 100%

FOREIGN TRADE

Exports—800 million to 900 million lb, imports—may rise to 40 million lb

PRICE

List price 31 cents a lb

COMMERCIAL VALUE

$1.1 billion for 1981 production

The long-suffering *p*-xylene business finally has a glimmer of good news. Although the temptation is to record it quickly before it goes away, the product actually may have made some basic, lasting improvements.

In its own lesser way, *p*-xylene has had the same shakeout as has its leading market, polyester fiber. Two producers are effectively out of production, and both plant use and prices are up. At the same time, *p*-xylene's important exports have resisted the general export decline among organics.

All told, U.S. producers of *p*-xylene probably consider themselves among the less damaged in the organic chemical world. Demand for their product is flat at 3.8 billion lb in 1981, but part of the reason is promisingly high capacity use in polyester fiber. Overcapacity in *p*-xylene has been reduced as one company, Shell Chemical, has left the business and another, Hercor, has stopped production for lack of raw materials.

Reflecting higher crude oil prices, producers have been able to raise the list price of *p*-xylene 4 cents a lb over a year ago. Although not all of the product moves at list price, the increase is enough to push production value more than 20% higher than 1980. One caution: Since the cost of feedstock went up at least as much and processing costs almost as much, little of the price increase is likely coming down to producers' bottom line as increased profits.

Much of *p*-xylene's renewed strength comes from stable export demand, which should match 1980 at more than 800 million lb. This is nearly a quarter of production, very high for a petrochemical. Although it's true that an important part of these exports eventually comes back to the U.S. as finished textiles, thereby curbing U.S. sales of *p*-xylene, export demand still can make or break producers.

Plant capacity for *p*-xylene isn't so large as it was last year, or in fact so large as it seems on paper. Shell's capacity has been gone for part of 1981. In Puerto Rico, Hercor's has been up and down depending on the fortunes of its feedstock source, financially troubled Commonwealth Oil Refining Co. The plant is now down. These output cuts, plus long maintenance shutdowns during the year, have reduced operating capacity for 1981 on average to about 5 billion lb, 10% below nameplate capacity of 5.5 billion lb.

The result then is a respectable capacity use rate for *p*-xylene in this year of renewed recession. If capacity in actual use most of the year is 5.0 billion lb, possibly 4.9 billion lb, and production is 3.8 billion lb, the operating rate then becomes a much healthier 76%, highest among the five leading basic petrochemicals.

In 1982, the operating rate is expected to hold to at least 75% because Hercor isn't expected to run very much. Demand, too, might pick up by 100 million lb or so as use in polyester bottle resins continues to grow relatively rapidly. If the second half of 1982 is an improving economic period, then production for 1982 might hit 4 billion lb again. That kind of outlook likely will help keep prices up after the current business recession.

Another factor that could strengthen *p*-xylene is a possible output ceiling forced by a crimp in supply of its feedstock, mixed xylenes. Mixed xylenes come mainly from oil refineries but also from olefins plant coproducts. Weak gasoline demand means less severe operation of refineries' catalytic reforming units, reducing slightly the xylenes supply from this source. Poor ethylene fortunes, spurring use of light hydrocarbon feedstocks in olefins plants, have reduced production of pyrolysis gasoline, the aromatics-rich byproduct stream. The result has been a lessening of mixed xylene supplies from this source.

As yet, feedstock constraints have not developed for *p*-xylene producers. But if this happens, the operating rate would have to drop. Producers then might get some price increases, which could more than offset unavoidably high capital charges per pound of product at low capacity-use levels.

Outside the bottle market for polyester, only small market increases are expected in 1982. Polyester film demand, roughly 10% of the total, will grow slightly, but not enough to do much for *p*-xylene. The rest of the U.S. market will depend on demand for polyester fibers, which is expected to move up.

xylenol feeds. The recycle is correspondingly rich in cresols. The addition of steam also improves the phenol yield another 4%. The net phenol yield can be as much as 57% from mixed cresol/xylenols.

Commercial development of the Dynaphen process has been limited to preliminary economic evaluations. The assumptions have been mainly that the process would be used with coal liquefaction plants and the analysis suggests that phenol recovery in a Dynaphen plant would increase total product value about 8.3%.

The economics of a stand-alone Dynaphen plant are highly dependent on feed composition. If the feedstock is cheap, as would be the case for by-product lignin from a pulping operation or for coal gasification process water, a stand-alone plant probably would be as profitable as it would be if it were an incremental investment for a large coal liquefaction plant. In any case, the Dynaphen plant is an adjunct to a primary chemicals producer rather than a primary process itself.

Joseph Haggin, Chicago

West Germany pursues active coal conversion development program

The West German dilemma with rapidly escalating oil prices is about the same as that of most other countries, except that it may be more intense. Like the U.S., West Germany has considerable coal reserves, about the only realistic long-term energy source available with the exception of nuclear power. Thus West Germany has an active coal conversion development program. The scope and current status of that program were outlined at the recent meeting of the American Institute of Chemical Engineers in New Orleans by Rudolf Specks and Arno Klusmann of Ruhrkohle Oil & Gas.

Specks and Klusmann estimate West German coal reserves to be sufficient for several hundred years at projected rates of consumption. There is also considerable industrial experience with large-scale coal conversion processes.

This experience has been used to advantage in a national program for coal conversion that is now in the demonstration-plant stage. It is not believed that any commercial plants will appear before the mid-1980's.

Coal conversion program has these projects finished or nearing completion . . .

Operator	Ruhrkohle A.G. Ruhrgas A.G. STEAG A.G.	PCV (Flick) Sophia Jocoba	Ruhrkohle A.G. Ruhrchemie A.G.	Deutsche Shell A.G.	Saarbergwerke A.G. Dr. C. Otto & Co.
Coal feed rate	7 tons/hour	1.5 tons/hour	6 tons/hour	6 tons/hour	10 tons/hour
Products	Syngas; SNG	Syngas	Syngas	Syngas	Syngas; SNG
Process	Modified Lurgi pressure gasification	Fixed bed	Modified Texaco pressurized coal dust gasifier	Shell-Koppers dust gasifier	Saarberg/Otto gasifier
Cost	$70 million	$11 million	$21 million	$44 million	$31 million
Schedule	Construction by 1979, tests through 1983	Construction by 1979, tests thereafter	Construction by 1978, tests thereafter	Construction by 1978, tests thereafter	Construction by 1978, tests thereafter

. . . in progress . . .

Operator	Ruhrkohle A.G. Veba Oel A.G.	Saarbergwerke A.G.	Gulf Mitsui Ruhrkohle A.G.	Exxon, DOE Electric Power Research Institute Kentucky Japanese consortium Phillips, Arco Ruhrkohle	DOE, Kentucky Ashland Oil Standard Oil (Ind.) Mobil, Conoco Ruhrkohle A.G. Veba Oel A.G.
Coal feed rate	200 tons/day	6 tons/day	30 tons/day	200 tons/day	180–480 tons/day
Process	Catalytic hard coal liquefaction	Catalytic hard coal liquefaction	SRC-II	EDS (Exxon)	H-Coal Process
Products	Gas Raw naphtha Middle distillate	Gas Raw naphtha Middle distillate	Gas Raw naphtha Middle distillate	Gas Raw naphtha Middle distillate	Gas; raw naphtha Middle distillate Heavy oil
Schedule	Operation begins in 1981	Operations begin in 1980	Operations began in 1978	Operations began in 1980	Operations began in 1980
Cost	$185 million	$13 million	$19 million	$150 million	$132 million
Location	West Germany	West Germany	Tacoma, Wash.	Baytown, Tex.	Catlettsburg, Ky.

. . . and being planned

Operator	Ruhrkohle A.G. Ruhrgas A.G.	Ruhrkohle A.G. Ruhrchemie A.G.	Deutsche Shell A.G.	Deutsche Texaco A.G.	PCV (Flick)	Saarbergwerke A.G.	Kerf	VEW
Coal feed rate	3 million tons/year	400,000 tons/year	300,000 tons/year	400,000 tons/year	500,000 tons/year	400,000 tons/year	100,000 tons/year	1.8 million tons/year
Process	Lurgi pressure gasifier	Texaco pressure gasifier	Shell Koppers	Texaco pressure gasifier	Fixed-bed gasifier	Saarberg/Otto	Saarberg/Otto	Partial gasification with air
Products	SNG Town gas Syngas	Syngas	Syngas	Syngas	Syngas for conversion to SNG	Syngas for combined power plant	Reducing gas	Fuel gas for combined power plant
Operation	1984	1985	1985	1985	1985	1985	1985	1985

Phillips has your Sulfur Chemical

Mercaptans

- Ethyl mercaptan
- n-Propyl mercaptan
- iso-Propyl mercaptan
- n-Butyl mercaptan
- sec-Butyl mercaptan
- iso-Butyl mercaptan
- tert-Butyl mercaptan
- n-Hexyl mercaptan
- Cyclohexyl mercaptan
- n-Octyl mercaptan
- tert-Octyl mercaptan
- tert-Nonyl mercaptan
- n-Dodecyl mercaptan
- tert-Dodecyl mercaptan
- tert-Tetradecyl mercaptan
- tert-Hexadecyl mercaptan
- tert-Mixed mercaptans
  - (C_9, C_{12})
  - (C_{12}, C_{14}, C_{16})
- 2-Mercaptoethanol
- Benzyl mercaptan

Sulfides

- Ethylthioethanol
- Di-n-butyl sulfide
- Di-tert-butyl sulfide
- Ethylthioacetate
- Phenylthioethanol

Disulfides

- Di-tert-butyl disulfide
- Di-tert-dodecyl disulfide
- Di-n-butyl disulfide

Polysulfides

- Di-tert-butyl polysulfide

Sulfones

- Sulfolane (anhydrous)
- Sulfolane-W
- Sulfolene

New Developmental Sulfur Chemicals From Phillips:

We can now produce developmental to commercial quantities of Di-n-propyl and Di-sec-butyl disulfides, Ethanedithiol, Thiodiglycol and Di-tert-nonylpolysulfide.

PHILLIPS 66

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Even then, the products are not expected to be really competitive with products from imported oil. However, despite the necessarily slow pace of development, alternative sources to imported oil for energy and chemicals are considered of enough importance to warrant national support. At the same time, the Ruhrkohle spokesmen note, the program must be simple and market-oriented.

As of now, about $450 million has been made available by the West German government for coal conversion technology development. Most of this money has gone into pilot plant construction and subsequent tests. The pilot plants have been divided roughly equally between coal gasification and liquefaction. The former have been primarily domestic but the latter have involved much international cooperation, particularly with the U.S.

About 35 processes have been developed in West Germany for gasification but only three have been commercialized. All the development effort since the 1973 Arab oil embargo has been based on these three processes as starting points.

The Lurgi fixed-bed gasifier has been in use the longest and is suited particularly for the production of town gas and substitute natural gas (SNG). This process may be used at elevated pressures, and the products may contain up to 10% methane. The Koppers-Totzek process is characterized by an entrained bed and can be operated at temperatures up to 2000 °C. There are no by-products, and the methane content is very small. The K-T process is considered particularly suitable for synthesis gas production in support of petrochemicals production. The Winkler fluid-bed gasifier is useful in processing lignite and other low-grade coals.

Five gasification pilot plants are now in operation or have been closed down following project completion. Although the official completion date isn't until sometime in the mid-1980's, the current claim is that all have been successful. There isn't much doubt about the success since they all involve established technology.

The principal purpose of the pilots appears to have been acquisition of design data for demonstration plants that are now in the planning and/or construction stage. In all of the gasification pilot plants, the principal product was synthesis gas. Two of them also produced SNG.

West German coal liquefaction development is based on extensions of the old Bergiua/Pier process, and on newer processes being developed jointly with U.S. participation. Five major liquefaction projects are under way and are scheduled to be completed by 1983. The foreign participants include the U.S. Department of Energy, U.S. private companies, the state of Kentucky, and some Japanese interests.

In addition to the projects completed or still under way, eight new proposals are now under consideration, six of them aimed at synthesis gas production. The production from envisioned commercial versions of the processes would be typically that from a feed rate of 600,000 tons per year of hard coal, and throughput would be matched to the needs of large fuels and chemical complexes.

The biggest single project is claimed by Ruhrkohle/Ruhrgas to be capable of processing 3 million tons per year of hard coal and would cost about $1.3 billion. A Ruhr industrial complex would be developed in stages and would provide gases for a public network as well as synthesis gas and SNG for industry.

The second biggest project is planned by Saarbergwerke to provide the Saar region with 800,000 tons per year of gasoline from coal. It is scheduled to be commissioned by 1987. The very high costs of the plants under consideration will require government participation and the formation of industrial consortia for the necessary capital. □

Coal-based chemicals competitive in 1980's

A dominant theme at the American Institute of Chemical Engineers meeting in New Orleans was the advent of coal-based petrochemical plants. According to Arthur S. Nislick, a vice president of C-E Lummus, it is quite likely that coal conversion can become competitive for production of petrochemicals in the 1980's.

This competitiveness is considered probable despite the current oil glut and the threat of price manipulation of crude supplies by the Organization of Petroleum Exporting Countries. Political instability, particularly in the Middle East, and the economic stress originating in high oil prices have conspired to give coal some advantages that this energy source otherwise might not have enjoyed for some time.

The new trend toward coal-based plants already has been established

Chemical & Engineering
NEWS
December 7, 1981

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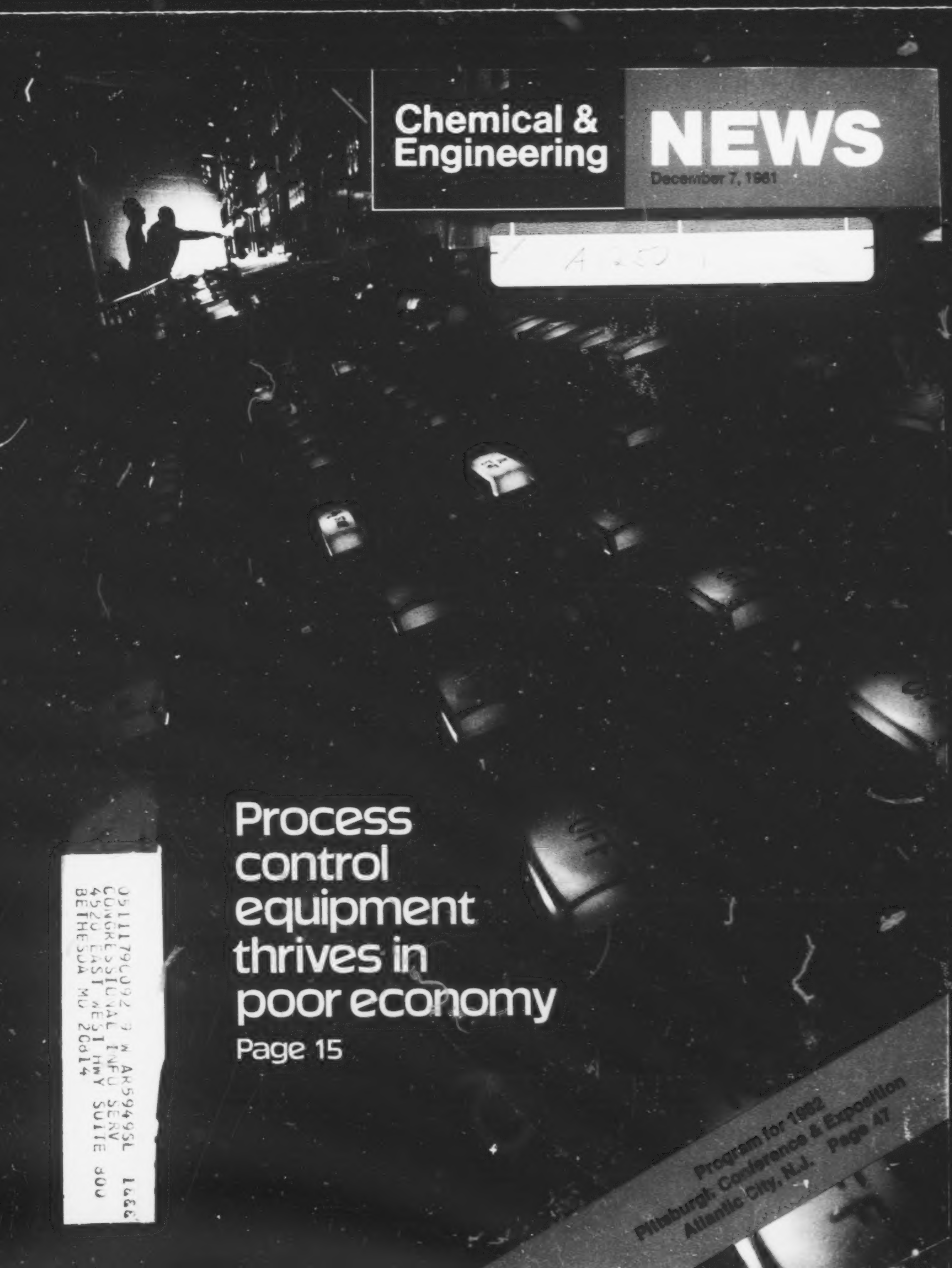

Process control equipment thrives in poor economy

Page 15

Program for 1982
Pittsburgh Conference & Exposition
Atlantic City, N.J. Page 47

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Chemical & Engineering NEWS

Cover: Control center of PPG Industries' Lake Charles, La., power plant, one of three that together generate about 75% of electrical requirements for the company's large chemical complex there. As an energy-saving measure, one generator is partly fueled by hydrogen gas produced as a by-product of chlorine manufacture

4 Letters

Concentrates
12 Business
20 Government
24 Science/Technology

The Departments
65 New Products
72 Books
88 Newscripts

News of the Week

- ***U.S. chemical companies' capital spending*** *on new plant and equipment rose in the third quarter but the boost will bring year's total only up to predictions.* ***Page 8***
- ***Present and future needs for stable isotopes*** *and derived radioisotopes is the subject of a workshop to be held at the National Academy of Sciences.* ***Page 9***
- ***Interferon,*** *potential anticancer and antiviral agent, increases damage done by some viruses in mice by concentrating the infection in the brain.* ***Page 9***
- ***John Harvey-Jones,*** *former product director of fibers division and of heavy organic chemicals division, named chairman of Imperial Chemical Industries.* ***Page 9***
- ***New hydrometallurgical process*** *to extract gold from a variety of ores will be developed by Haber in joint venture with a Houston mining firm.* ***Page 10***
- ***U.S. nuclear industry quality control*** *programs termed inefficient by Nuclear Regulatory Commission chairman.* ***Page 10***
- ***The U.S.S.R. has ample gas reserves*** *and is not likely to be a net energy importer during this decade, Office of Technology Assessment study concludes.* ***Page 10***

Business

- ***Makers of process control equipment*** *are thriving despite the recession; retrofitting of existing plants makes up for loss in new plant construction.* ***Page 15***

Government

- ***District court judge*** *orders EPA to promulgate landfill regulations specified under 1976 resource conservation act.* ***Page 22***

Science

- ***Genetic research to improve nutritional value of corn*** *yields variant that overproduces threonine, reveals structure of plant storage protein zein.* ***Page 31***
- ***Joel Hildebrand's 100th birthday fete*** *highlighted by endowment of chair in chemistry at Berkeley, establishment of annual ACS award in his honor.* ***Page 33***
- ***Interest in high-performance liquid chromatography*** *of proteins and peptides evidenced by symposium attendance.* ***Page 34***

Technology

- ***Cellulose-to-ethanol projects*** *are beginning to show promise for commercialization but disappearing federal support for synfuels development is hindrance.* ***Page 35***
- ***Department of Energy is winding down*** *its synthetic fuels development program to focus on high-risk, high-payoff R&D.* ***Page 42***

Meetings

- ***1982 Pittsburgh Conference & Exposition*** *to be held in Atlantic City features lengthy technical program, lab equipment exhibits, and social functions.* ***Page 47***

CHEMICAL CAPITAL SPENDING STILL SLUGGISH

Despite a pickup in the third quarter, U.S. chemical companies' capital spending on new plant and equipment—their largest outlay of funds after ordinary running expenses and taxes—is turning in a sluggish year. The money is up, but it helps to wink at inflation.

Fresh data from the Conference Board, a New York City business research group, show a stronger tone to capital spending in the third quarter than in the first half of 1981. However, the strengthening only brings the industry close to its own predicted spending rate for the year, which is decidedly soft.

The Conference Board finds that chemical capital spending through nine months of 1981 is up 7% from the same period in 1980. That's pretty close to the 8% pickup for 1981 that basic chemical companies projected at the end of last year (C&EN, Dec. 8,1980, page 19). And it is higher than the 4% gain in actual spending for the first half of the year (C&EN, Sept. 7, page 15).

However, a 7% gain in capital spending barely keeps up with inflation. In other words, in physical project terms the industry's plant investment rate flattened out in 1981.

Specifically, the Conference Board reports that chemical capital spending in the third quarter in current dollars hit $3.16 billion, 9% more than in the third quarter last year. This brings capital spending for the first nine months 7% ahead of spending for the same period in 1980.

In constant 1972 dollars, the chemical companies surveyed by the Conference Board spent $1.62 billion in the third quarter, an increase of just 4% from the third quarter last year. The constant-dollar spending increase is a mere 1.1% for the year.

One capital expenditure: fractionating column on way to B. F. Goodrich plant

Appropriations (money to be spent in the future), like spending, picked up in the third quarter. Current-dollar appropriations by chemical companies increased 24.5% to $3.39 billion from the same period last year. However, this runup in the third quarter served only to get appropriations back on track for the year. For the first nine months, appropriations were only 4.4% ahead of the first three quarters of 1980.

Constant-dollar appropriations, in spite of a rise in the third quarter, still are losing ground for the year. Third-quarter constant-dollar appropriations increased 18.4% from the same period last year to $1.74 billion. However, for the nine months to date, constant-dollar appropriations are off 1.6% from their levels of a year ago.

The backlog of unspent appropriations also increased at the end of the third quarter, as it has for some time because of restrained spending. The current-dollar backlog of $9.64 billion at the end of the quarter was 5.1% greater than at the end of the third quarter last year. It was also 1.7% ahead of the $9.48 billion backlog at the end of second-quarter 1981.

In constant dollars, the backlog in the third quarter was $9.43 billion, 2.7% ahead of last year and 0.9% greater than in second-quarter 1981.

For the rest of 1981, capital spending prospects could be worse, in light of the falling economy. With their cash intake pared, chemical companies may well take a second look at some spending projects. And for 1982, the outlook is for more of the same at best. □

Rates of chemical capital spending and appropriations both increased in third quarter

	1981			1980					
$ Millions	Third quarter	Second quarter	First quarter	Fourth quarter	Third quarter	Second quarter	First quarter	% annual change, third quarter	% annual change, first nine months
Appropriations									
Current dollars	$3389	$3038	$2939	$3193	$2723	$3201	$3043	24.5%	4.4%
Constant dollars[a]	1737	1610	1568	1696	1466	1789	1742	18.4	−1.6
Spending									
Current dollars	3158	2751	2856	2714	2898	2681	2613	9.0	7.0
Constant dollars[a]	1618	1458	1526	1442	1560	1499	1495	3.7	1.1
Backlog[b]									
Current dollars	9641	9480	9417	9819	9173	9362	8855	5.1	5.1
Constant dollars[a]	9431	9348	9315	9529	9186	9288	9005	2.7	2.7

a 1972 dollars. b Backlog of unspent appropriations at end of period. **Source:** Conference Board

Process control equipment ignores recession

Energy management steps, retrofitting of existing plants tide control equipment makers over slowdown in new plant construction

Stephen C. Stinson
C&EN, New York

If there's an economic recession going on in the U.S., the makers of industrial process control equipment don't know it yet.

For example, a study of process control equipment markets by Predicasts, based in Cleveland, indicates that dollar sales of such equipment have forged ahead at 5% annual real growth for the past 15 years, a trend that seems likely to continue unbroken through 1985 and beyond.

Even this solid dollar growth, which is almost double the yearly increase in the gross national product, understates the health of some market segments. A second study by Creative Strategies, San Jose, Calif., concludes that unit sales of some digital electronic equipment will soar 25% per year through 1985, though continuing declines in the prices of electronic devices will slow dollar growth.

The reason for this successful bridging across bad times in manufacturing industries is that most firms continue upgrading materials, energy, and labor use efficiencies at existing plants, even if they're building few new plants.

The future looks even brighter. In addition to a return to new plant construction with economic recovery in coming years, synthetic fuels projects could start using a lot of costly instrumentation and control. Initial fears that withdrawal of government support from synfuels would force cancellation of many projects now seem overpessimistic. Private industry is picking up the slack for many of these projects.

The U.S. chemical industry will continue to buy a quarter of all process control equipment sold in this country. Chemical purchases will rise from $1.2 billion in 1981 to almost $2 billion in 1985, according to Predicasts, which assumes a 7% annual inflation rate.

The next largest purchaser, in terms of dollar volume, is the oil industry, whose $860 million of process control purchases this year will be 14% of the market. Oil companies will buy $1.5 billion worth in 1985, says Predicasts analyst Dean M. Peters, raising their share to 18%.

Fastest growing in use of process control equipment is the rubber and plastics industry, where automation of such operations as injection and blow molding, extrusion, and compounding will double this year's $50 million in orders by 1985.

Process control equipment includes computers and programable controllers; temperature, pressure, flow rate, and liquid level sensors, transmitters, and controllers; materials analyzers; and valves. Sales of electronic sensors, transmitters, and

Electronic devices will show biggest growth over the next few years

Control equipment	Sales[a] ($ millions) 1981	Sales[a] ($ millions) 1985	Annual growth rate, %[b]
MEASUREMENT, DISPLAY & CONTROL	$3721	$ 5,900	12.2%
General purpose[c]	**403**	**630**	**11.8**
Electronic	296	470	12.2
Pneumatic	107	160	10.5
Process control computers	**733**	**1,130**	**11.4**
Temperature instruments	**597**	**950**	**12.3**
Electronic	296	510	14.6
Mechanical	92	130	9.0
Primary temperature sensors	209	310	10.3
Pressure instruments	**301**	**470**	**11.8**
Electronic	100	170	14.1
Mechanical	200	300	10.6
Flow & level instruments	**676**	**1,090**	**12.7**
Differential pressure	302	480	12.3
Electronic	139	250	15.8
Other	235	360	11.3
Material analysis equipment	**265**	**420**	**12.2**
Chromatographic	58	90	11.7
Infrared	64	100	12.0
Oxygen analyzers	55	90	13.0
pH and other instruments	89	140	12.1
Other instruments, parts & accessories	**$ 746**	**$ 1,210**	**12.8%**
Other physical variables	89	130	10.0
Parts & accessories	658	1,080	13.2
PROGRAMABLE CONTROLLERS	**330**	**1,000**	**32.0**
VALVES	**1401**	**2,210**	**12.1**
Control	**676**	**1,070**	**12.2**
Pneumatic	442	680	11.4
Electric	103	170	13.3
Electric/hydraulic	30	60	19.4
Other	102	160	12.1
Regulating	**490**	**770**	**12.0**
Pressure	234	380	12.9
Flow	149	230	11.5
Temperature	36	50	8.4
Other	71	110	11.7
Solenoid	**235**	**370**	**12.0**
Two-way	178	280	12.0
Other	57	90	12.1
TOTAL SALES	**$5452**	**$ 9,110**	**13.7%**
Less imports	**$ 216**	**$ 380**	**15.1%**
Plus exports	**$ 758**	**$ 1,350**	**15.5%**
TOTAL SHIPMENTS	**$5994**	**$10,080**	**13.9%**

a Amounts do not add to totals and subtotals because of rounding. b Includes a 7% per year estimate for inflation. c Includes controllers, indicators, and recorders for control rooms.
Source: C&EN calculations from Predicasts data

Chemical industry buys 25% of all process control equipment

Industry	Sales[a] ($ millions) 1981	Sales[a] ($ millions) 1985	% growth rate[b]
Chemicals	1214	1980	12.3
Petroleum	857	1500	15.0
Electric & gas utility	786	1360	14.7
Primary metals	732	1220	13.6
Paper & pulp	352	510	9.7
Food & beverage	341	550	12.7
Stone, clay & glass	182	280	11.4
Water & sewage	104	160	11.4
Textiles	59	110	16.7
Rubber & plastics	49	100	19.3
Mining & other[c]	235	370	12.0
TOTAL SALES	**$4911**	**$8140**	**13.3%**
Net exports[d]	**$ 541**	**$ 970**	**15.7%**
TOTAL SHIPMENTS	**$5452**	**$9110**	**13.5%**

a Amounts do not add up to totals because of rounding. b Includes a 7% per year estimate for inflation. c Includes foundry and pharmaceutical industries. d Excess of exports over imports. **Source:** C&EN calculations from Predicasts data

controllers will grow at faster rates than pneumatically operated ones, Peters says, because of greater ease of use with computers, microcomputers, and microprocessors in such concepts as hierarchical and distributed control. Indeed, some equipment producers are moving away from pneumatic controls, especially in Europe, where a return from the currently depressed market is expected to emphasize electronic controls.

Still, pneumatic equipment will fill definite major roles through the end of the century. For example, where compressed air service already exists at a plant site, economics may favor continuing with pneumatics. Too, some managers are prejudiced against outlying electronic devices in plants that process flammable or other hazardous materials. Pneumatic signals also can be converted to electronic signals, thus making possible use of computers in plants with pneumatic controls.

But at least one argument against electronic controls may not hold up. This argument turns on the greater cost of individual pieces of electronic equipment compared to pneumatic equipment. Industry observers counter that the installed costs of each still favor pneumatic approaches, but not by very much.

Though about 1000 firms serve the process equipment control market, Predicasts points out that a handful of U.S. companies have most of the business. Only a few of these are publicly held companies and release financial information. Among these publicly held firms, process control sales cut across many divisions and are difficult to separate. C&EN has estimated 1980 sales of the leaders where these were unavailable or hard to isolate.

The apparent sales leader is Honeywell of Minneapolis, whose 1980 sales are estimated at $670 million. Second is Fisher Controls International, a joint venture company formed in 1979, owned 67% by Monsanto and 33% by General Electric Co. Ltd. of the U.K. (unrelated to the U.S.'s General Electric). Fisher sold $593 million worth of process control equipment in 1980. Third ranked is Foxboro Co., Foxboro, Mass., whose sales of process control equipment last year came to $484 million. Predicasts says that such sales are 95% of Foxboro's total.

Hewlett-Packard, Palo Alto, Calif., is fourth; its 1980 process control equipment sales are estimated at $394 million. Fifth is Texas Instruments, Dallas, which likewise does not break out process control equipment sales, but which C&EN estimates at $316 million in 1980. These five largest firms among the top sellers to the industrial process control equipment market probably accounted for 35% of sales to the U.S. and world markets.

Less clear are the standings of the next five largest sellers of industrial process control equipment. Gould of St. Louis sold about $252 million of equipment in 1980. General Electric (the U.S. company) sold about $245 million worth. Sales of Westinghouse are estimated at $270 million. Taylor Instrument, subsidiary of Sybron Corp., Rochester, N.Y., sold about $195 million, in addition to $20 million of consumer instrument sales. Beckman Instruments, Fullerton, Calif., presently the object of acquisition by SmithKline Corp. (C&EN, Nov. 30, page 8), sold about $195 million. The 10th largest company in size of process control instrument sales, Fischer & Porter, Warminster, Pa., sold $170 million worth, in addition to $15 million of other products to other industries.

Supplying the industrial process control equipment market is a fairly profitable business. Foxboro's earnings were 6.3% of sales in 1980, 7.2% in 1979, and 8.1% in 1978. A company supplying this industry must put a certain amount of profits into development of new equipment for coming years, in addition to paying out dividends, so that it can keep abreast of technology and maintain a steady pattern of earnings over the long-term.

Monsanto revealed that Fisher Controls had an operating profit of 12% of sales in 1980 and 9% in 1979. If one assumes a 50% share for income taxes, these figures might have been equivalent to net earnings of 6% of sales in 1980 and 4.5% in 1979. Thus, these results would not be too much different from Foxboro's.

Similarly, Sybron indicated equivalent net earnings of 3% of sales for Taylor Instrument in 1980, 3.2% in 1979, and 5.3% in 1978, likewise assuming income taxes of 50% on operating profits. Besides Foxboro, the only major independent, publicly held process control equipment producer is Fischer & Porter, which reported net earnings of 9.6% of sales in 1980, 0.5% in 1979, and 3.1% in 1978. Spokesmen for Fischer & Porter blame low earnings on high interest rates and strength of the dollar, which has increased overseas prices of U.S. exports and lowered dollar values of profits brought back to the U.S.

In addition to Monsanto, companies that have experience specifying process control equipment for their own chemical plants and refineries have entered the business. For example, Phillips Petroleum Co. owns Applied Automation, Bartlesville, Okla. Du Pont develops and produces materials analyzers through its analytical instrument division. Among engineering construction firms which install control systems in addition to building plants for process industries, Babcock & Wilcox, a subsidiary of McDermott, owns Bailey Controls Co., Wickliffe, Ohio. And Forney Engineering Co., Addison, Tex., is a subsidiary of Foster Wheeler Energy Corp.

Even if a large chemical company is not in the process control business, though, many design and build their own equipment when the market would be too small to interest a control equipment maker, or when the use is proprietary and the company wants to keep the project proprietary. For example, when microprocessors first appeared, Union Carbide's central engineering department, serving the chemical and plastics division worldwide for design and construction services, used one to make a microcomputer-guided controller based on a gas chromatographic (GC) analyzer at the department's shops in South Charleston, W.Va.

Similarly, when concern first arose about vinyl chloride, detectors for the monomer were unavailable commercially. The Carbide department designed and installed monitors at company plants where the substance was used and coupled the monitors with computer-guided estimation of worker exposure over whole plant sites. When computer-based GC analyzer/controllers and vinyl chloride monitors became available commercially, the company's central engineering operation got out of the business.

Carbide's central engineering department still makes its own flowmeters and materials analyzers for certain proprietary catalyst streams. Measuring flow rates of gas-solid mixtures is a tough engineering problem, so the company devised its own solution. Because the catalysts are proprietary, Carbide has kept the materials anayzer needed to gauge catalyst activity to itself. Although not formally in the process control business, Carbide does build and sell a few, specialized devices as an accommodation to customers and some other buyers.

The technology edge of U.S. process control equipment firms traditionally has given this country a favorable balance of trade in such equipment. Predicasts expects this trend to continue over the next 15 years, though increasing use of electronic devices, coupled with Japanese advances in electronics, will lead to increasing penetration of the U.S. market by imports. Price competition by foreign valve makers also is expected to open the U.S. market further to imports.

Predicasts analysts see imports growing at slightly more than 15% annually, assuming 7% inflation rates. Predicasts data indicate the U.S. will import $216 million worth of process control equipment in 1981, or 3.8% of total sales here of $5.7 billion. Imports will grow to $380 million in 1985, the firm predicts, which will be 4% of the $9.5 billion market.

Exports will increase at 15.5% annually, Predicasts analysts say, again assuming 7% inflation. The company's data indicate that U.S. producers will export $758 million worth of process control equipment in 1981, amounting to 12.6% of their total sales. Exports will rise to $1.4 billion in 1985 to account for 13.4% of U.S. producers' sales.

Cost of process control for a chemical plant has averaged 9% of total capital investment, including hardware, engineering, and project management costs, for the past 10 years, industry analysts say. This expense ranges from 6% of capital investment for relatively uncomplicated plants to 15% in highly instrumented synfuels plants now being built.

This relative constancy of process control costs results from increased use of minicomputers and microprocessors as well as of electronic instruments with continually improving capacity. Thus companies are buying fewer components at higher prices to accomplish more in the way of control.

The installation of energy-efficient control systems at some plants does push the proportion toward 15% at some plants, according to C. Thomas Carroll, principal instrument engineer at Foster Wheeler Energy Corp., Livingston, N.J. Energy efficiency means lower allowed pressure drops, he says, which means specifying more accurate and, thus, more costly valves. The number of on/off valves in such a plant must be increased,

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Detach and return by January 4, 1982 to the General Chairman.

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Papers to be presented

Carroll says, because plant managers want to be able to shut down a plant with equipment still hot and materials recirculating in case of emergencies. Possible needs to operate plants at less than rated capacities and still conserve the use of energy, as in today's economic downturn, also lead to installation of more accurate, more expensive sensors such as flowmeters.

Besides more powerful electronic hardware, however, advances in process control theory also may contribute to keeping control costs down. Though control theory is always in advance of practice, W. Harmon Ray, chemical engineering professor at the University of Wisconsin, Madison, says that availability of increased, low-cost computing power makes it worthwhile to apply previously impractical concepts. Three areas where Ray foresees new applications of control theory are complete, centralized control of entire plant complexes; on-line production schedules at plants that use the same equipment to make many products; and use of functions based on partial differential equations rather than simple differential equations to describe what goes on in reactors.

Centralized control of plant complexes means that engineers must apply ideas on nonlinear interactions among different processes at the complex. In this way, plant managers can adjust the operating point of the entire complex continuously, Ray says, rather than concentrate on one or two critical points. In an ethylene plant, for example, managers can vary feedstocks to crack larger proportions of heavy liquids or add large amounts of butanes. They also can change relative amounts of products by adjusting furnace conditions. But Ray points out that these changes may alter such factors as rate of furnace coke buildup, and therefore maintenance costs. By improving the model of how the plant works, managers can find what are net economic consequences over long periods of decisions to change feedstocks or product slates.

Ray's second point, scheduling of production equipment use, already has been adopted to some extent by chemical firms here. Mallinckrodt uses such a system to schedule filling machine use to package the 200 or so reagent chemicals the company distributes from its Paris, Ky., plant (C&EN, Aug. 24, page 8). But Ray insists that such scheduling is not so widespread as it could be, and he points to development of computer programs by Swiss academicians for drug and dyes production as examples of what the future may hold.

Partial oxidation of hydrocarbons, as of naphthalene to phthalic anhydride, is an example of Ray's point that partial differential equations may find use to model such processes. Ray says these processes run close to thermal runaway, and that better modeling might bring greater efficiency through improved control. At present, he says, engineers consider only such simple parameters as change in reactor temperature with respect to time. A better model would combine equations describing, for example, change in temperature with respect to time, linear distance through the reactor, and radial distance from a central axis to the outer wall, with the other two factors held constant in each of the three functions. □

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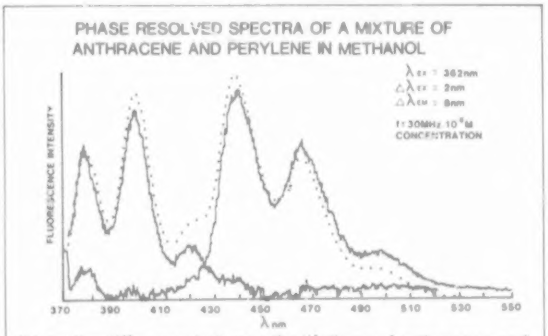

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Chemical & Engineering NEWS

December 14, 1981

Monoclonal antibodies help probe chemistry of the immune system
Page 28

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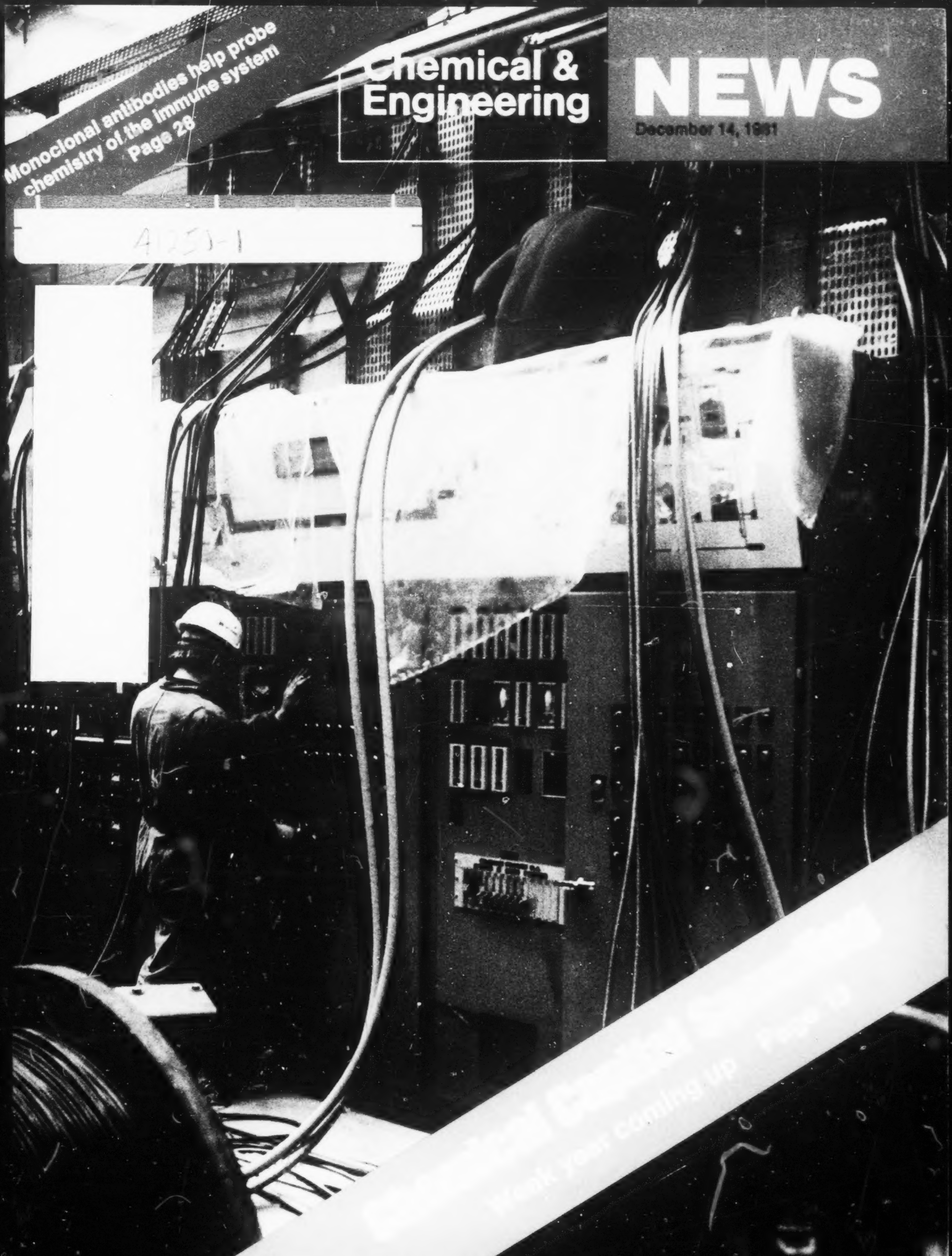

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December 14, 1981
Volume 59, Number 50
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Chemical & Engineering NEWS

Cover: Installation of a computer in the control room of W. R. Grace's new plant in Selestat, France, for battery separators

4 Letters
5 Editor's Page

Concentrates
10 Business
20 Government
26 Science/Technology

The Departments
33 ACS Comment
35 Meetings
42 New Products
60 Newscripts

News of the Week

- ***Du Pont will sell*** *some of its natural resources, including coal assets, to reduce the debt incurred to finance the Conoco acquisition, company officials say.* ***Page 6***
- ***Arkansas law that requires teaching of creationism*** *along with evolution in public schools appears to be heading for defeat in trial resulting from ACLU suit.* ***Page 6***
- ***Clayton F. Callis*** *elected chairman of ACS Board of Directors; committee chairmen named for 1982.* ***Page 7***
- ***Use of nitrites in curing meat*** *should be reduced, National Research Council panel recommends.* ***Page 7***
- ***Presidential science adviser Keyworth*** *gives little hope that Administration will ease up on reducing R&D funding.* ***Page 8***
- ***Second-quarter 1982*** *will see the turnaround of the recession, National Association of Purchasing Management says.* ***Page 8***
- ***Annual Chem Show*** *of chemical process equipment and instrumentation returns to New York City Coliseum.* ***Page 8***

Business

- ***Chemical capital spending*** *will be up only 6% in 1982 for major U.S. basic chemical companies, following a minuscule 1% spending increase in 1981.* ***Page 13***
- ***Chemical wastes will be stored*** *in a worked-out limestone mine, if plans made by PPG Industries go through.* ***Page 15***

Government

- ***Evidence of use of fungal warfare agents*** *in Southeast Asia by Soviet surrogates has been sketchy, has yet to stand up to scientific scrutiny.* ***Page 21***
- ***Action on bills dealing with long-term disposal of nuclear waste*** *is being held up because of serious differences.* ***Page 24***

Science

- ***Ancient Greek bronzes*** *were studied by modern analytical techniques and chemically treated to halt corrosion after their discovery off the coast of Italy.* ***Page 27***
- ***Monoclonal antibodies,*** *prepared by fusing cancer and antibody-producing cells, are key tools for researchers studying how antigens and antibodies interact.* ***Page 28***
- ***Structure diagrams*** *now can be used to search* Chemical Abstracts. ***Page 30***

Technology

- ***Continuous peroxide process*** *at new Witco Chemical plant in Texas relies on recent advances in computerized process control for safe and efficient operation.* ***Page 32***

Books

- ***"The Nobel Duel,"*** *by Nicholas Wade, details the story of the competitive research behind the 1977 Nobel Prize for Medicine shared by Schally and Guillemin.* ***Page 48***

Chemical & Engineering News

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Letters

Earth's changing temperature

SIR: Your article in C&EN, Oct. 26, page 7, entitled "Warming trend tied to atmospheric CO_2" leads the reader to conclude that there is scientific evidence that the average temperature of Earth is increasing. Just the reverse is true, in the northern hemisphere at least, as the data in your article itself suggest. You state that during the fall and winter the temperatures between 55° and 80° north latitude "were about 5 °C lower than in the 1930's."

Analysis of current trends has led a number of scientists to speculate that a new "mini" ice age may be in the offing. This cooling trend, which began about 1940, has had severe effects in the Arctic. According to Soviet researchers, the ice-covered area between Greenland and the eastern tip of the Soviet Union has, on an average, increased 600,000 sq km during the summer season. The mean annual air temperature over the Kara Sea has fallen 3 °C. The result of increased sea ice has generally shortened the summer season on the Soviet Union's Arctic coast by almost a month.

Whereas the northern hemisphere appears to be definitely in a cooling phase, the southern hemisphere appears to be warming up for reasons nobody understands. If these climate changes were associated with society's activities and the buildup of CO_2, one might expect the northern hemisphere to be warming up rather than the southern hemisphere since the northern hemisphere is more heavily industrialized. The fact is that Earth has undergone cyclic temperature changes entirely independent of humanity's activities for thousands of years of recorded history, and evidence indicates that these processes have gone on for many millions of years. The reasons for these changes are not at all understood, and there is no evidence that it can be tied to any of society's activities.

Ponca City, Okla. James C. Kirk

Generating method not new

SIR: In the Oct. 26 issue of C&EN, page 17, a method for generating methane based upon reaction of graphite with water vapor or alkali hydroxides was reported by Gabor Somorjai and Alejandro Cabrera of Lawrence Berkeley Laboratory.

The method described is not new. Reaction of water vapor or alkali hydroxides with graphite at 250 °C to form methane is typical of some carbides. The formation of aluminum and beryllium carbides along with their hydrolysis to methane was reported as early as 1897.

According to available literature, a temperature of 1200 °C is required to initiate the carbon aluminum reaction to form aluminum carbide. These compounds are pyrophoric and sublime at approximately 2000 °C.

The high temperature (3000 to 3500 °C) required to manufacture graphite from coal or coke provides a reaction atmosphere for formation of carbides. Graphite is the condensate from the heat treatment of coal or coke. This heat treatment provides ample opportunity for formation of aluminum carbide with aluminum in coal ash at 1200 °C, sublimation of aluminum carbide at 2000 °C, and coatings of the carbide with heavy condensate to prevent spontaneous ignition.

Ten years ago, a colleague and I submitted a proposal to the U.S. Bureau of Mines concerning reaction of coal and fly ash at high temperature to produce methane during hydrolysis of the aluminum carbide formed. Our proposal did not include the possibility of a salable product.

My congratulations to the researchers. I think their work demonstrates originality and this will be required to solve energy problems in America.

Morgantown, W.Va. Kenneth B. McCaskill

Doughty/Freeman reaction

SIR: In a recent issue of C&EN (July 13, page 4) B. W. Giesemann reports, as "another violent reaction," the reaction of trichloroacetic acid and copper wool in DMSO. We wish to call attention to the fact that this reaction is analogous to the reaction described by H. V. Doughty and B. Freeman [*JACS*, **43**, 703 (1921)] as a convenient means to dissolve a copper deposit from a silver cathode. The Doughty and Freeman reagent consisted of a 10% solution of trichloroacetic acid in aqueous ammonia (one part concentrated ammonia and one part water).

We have repeated the Doughty and Freeman reaction, adding copper wool to the reagent mixture. The copper dissolved smoothly, the solution taking on the color of the cupric ammine complex. According to Doughty and Freeman, in this reaction three atoms of Cu require two molecules of trichloroacetic acid. We have also tested the reaction of copper with trichloroacetic acid dissolved in a solvent (a) composed of equal volumes of DMSO and H_2O and in solvent (b) compound of equal volumes of acetonitrile and H_2O. With both of these solvents a reaction takes place. With solvent (a) the resultant solution was initially green in color while in the case of solution (b) the solution was colorless.

As a final experiment we repeated the Giesemann reaction, adding copper wool to the solution of the trichloroacid in DMSO. Although the bottom of the Pyrex erlenmeyer where the wool rested became definitely hot, the reaction proceeded quietly. The resultant solution was strongly yellow in color.

We acknowledge the valuable assistance of Star Glad with these experiments.

Thomas G. Dunne
Arthur F. Scott
Reed College, Portland, Ore.

Correction

- Nov. 30, page 30: The University of Minnesota Institute of Technology is not among the schools that have raised their tuition this year to increase engineering faculty salaries.

Chemical capital spending will stay weak

After holding down global capital expenditures to a 1% gain in 1981, major U.S. chemical companies plan a 6% increase in 1982

William F. Fallwell
C&EN, New York

A few heads must be shaking in Washington, D.C. After giving U.S. chemical and other industries a Whitman's Sampler-sized box of tax sweeteners to encourage job-creating investment, the government is being greeted with very modest gains in capital spending plans for 1982.

It isn't quite so illogical as it looks, however. Companies have universally praised the new incentives from Washington but are waiting until two things happen to take advantage of them. The economy has to start growing again, and companies' large excess plant capacity has to dry up.

Since both of these developments look somewhat distant at this mid-recessionary moment, companies are keeping a decidedly light hand on the spending button. C&EN's annual survey of 17 leading basic chemical companies finds that, on average, they plan just a 6% increase in worldwide outlays for new plant and equipment in 1982 from 1981. These plans follow a tiny 1% spending increase in 1981 from 1980, much less than the 8% gain originally budgeted (C&EN, Dec. 8, 1980, page 19).

Both of these annual increases fall considerably short of inflation. This means that, in reality, capital spending in the chemical industry has shrunk two years in a row after the last major gain, a 23% increase in 1980.

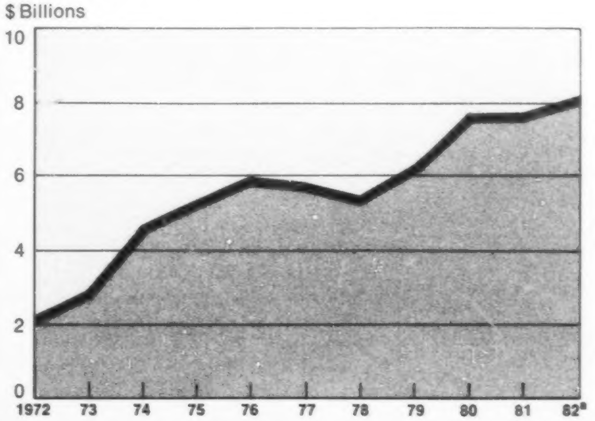
Even with such restraint, basic chemicals and polymers in the U.S. are swimming in extra plant capacity. Completion of projects started in balmier times several years ago has pushed up overall plant capacity in basic chemicals faster than the rise in production in 1981. In C&EN's latest capacity use survey (C&EN, Oct. 12, page 12), plant use in basic chemicals in the third quarter ran a disappointing 72% of the nameplate maximum, down from a none-too-good 74% in the first quarter.

So, despite hopes in the past few years that modest capital spending would combine with normal product growth to yield high capacity-use rates in the early 1980's, plants in many products are running at even lower rates than in the recessionary mid-1970's. The main reason is that product growth has been nonexistent for most basic chemicals since 1979. Although industry analysts fully expected slower product growth in the 1980's, no one expected a complete halt for three years.

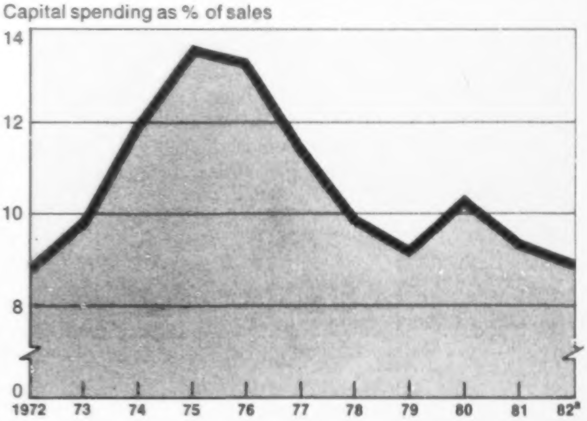
The slack in capital spending comes even clearer in the ratio of spending to industry sales. Over the past three decades, this ratio has ranged from about 8% in slow years to 5% in red-hot spending booms. Right now, the ratio is diving toward the bottom of the range. It dropped to 9.5% this year from 10.4% in 1980 and is heading for 9.0% in 1982. If the 1982 estimate is accurate, next year will be the lowest since 8.9% in 1972, the weakest capital spending year of the past decade.

Within the spending totals, several interesting internal shifts are under way. One is immediately apparent from the company data. Despite widespread predictions of a fresh boost in capital spending outside the U.S. this decade, just the opposite has occurred for most companies in 1981 and 1982. The result is that, for the first time in recent years, capital funds tagged for projects in the U.S. make up more than 80% of the total worldwide budgets for chemical companies. For 1982, U.S.-bound money will be 81% of the total, following 80% in 1981. The old rule of thumb was about 75% of capital funds for U.S. projects.

Chemical capital spending will increase only slightly in 1982...



...and will remain notably low as a percentage of chemical sales



a C&EN estimate. **Source:** Combined data from major chemical companies

1981 capital spending is 7% less than first budgeted

$ Millions	1982 Worldwide	1982 U.S.	1981 Worldwide	1981 U.S.	Worldwide: 1981 Planned[a]	Worldwide: 1980	Worldwide: 1979	Worldwide: 1978	Worldwide: 1977	Change from previous year: 1982	Change from previous year: 1981
Air Products	$ 400	$ 340	$ 323	$ 275	$ 390	$ 364	$ 246	$ 200	$ 143	24%	−11%
Akzona	68	68	60	60	60	64	54	42	35	13	−6
Allied Corp.	700	550[b]	600	470	675[b]	533	409	502	465	17	13
American Cyanamid	185	150	185	150	205	196	235	251	235	0	−6
Celanese	400	280[b]	390	275	350	253	245	248	243	3	54
Diamond Shamrock	540	524	537	520	450	381	257	319	390	1	41
Dow Chemical	1000	650	1100	715	1400	1184	1268	1075	1163	−9	−7
Du Pont[c]	1400	1200	1300	1100	1300	1279	864	714	704	8	2
Ethyl Corp.	120	100	120	100	130	156	123	96	88	0	−23
W. R. Grace	800	711	686	613	650	657	511	309	279	17	4
Hercules	180	160	160	143	220	229	186	116	127	13	−30
Monsanto	660	575	600	525	800	781	566	480	607	10	−23
Olin	160[b]	150[b]	160	150	170[b]	172	161	163	208	0	−7
Pennwalt	95	90	50	43	70	56	67	62	46	90	−11
Rohm & Haas	na	na	150	120	150	93	68	66	79	na	61
Stauffer Chemical	215	204	256	246	200	246	239	201	193	−16	4
Union Carbide	1300	910	1200	800	1150	1129	831	688	805	8	6
TOTAL FOR 16 FIRMS[d]	**$8223**	**$6662**	**$7727**	**$6185**	**$8220**	**$7680**	**$6262**	**$5436**	**$5731**		
ANNUAL CHANGE	**6%**	**8%**	**1%**	**6%**	**7%**	**23%**	**15%**	**−5%**	**−3%**		

a Earliest estimate. b C&EN estimate. c Excludes Conoco. d Excludes Rohm & Haas. na = not available.

Home-country spending is outpacing worldwide totals for U.S. chemical companies in both 1981 and 1982. Domestic spending is still up 6% in 1981, whereas the worldwide gain is just 1%. This means, of course, that non-U.S. spending has fallen hard in 1981, 17% from 1980. For 1982, companies plan just a 1% increase in spending outside the U.S.

A good example of the international funding switch is Monsanto. A year ago, the company still estimated that 25% of its 1981 spending would go outside the U.S. Now the company estimates its non-U.S. budget at 13% of the total after making major cuts in both U.S. and non-U.S. segments.

An exception is Celanese, which is bearing out the old prediction of large increases in money for new foreign plants, especially over natural gas fields. In both 1981 and 1982, Celanese estimates that about 30% of its capital spending will be outside the U.S., compared to 23% in 1980. The company has major new projects in Canada, Mexico, Brazil, and Saudi Arabia. Celanese's overall capital budget also is bucking the tide with a 54% increase in 1981 to a level sustained for 1982.

Besides the geographic reshuffling of capital funding, another internal shift may be in the offing. Dow Chemical suggests that an important

West German spending in the U.S. to fall

Capital spending in the U.S. by the three largest West German firms will drop sharply in 1982, according to their current plans. This is a reversal of 1981, when capital spending in the U.S. by American Hoechst, BASF North America, and Mobay and other Bayer subsidiaries rose from previous-year levels.

Planned capital expenditures by these companies in 1982 will total about $473 million, a 14% decrease from 1981 expenditures.

However, one company—American Hoechst, the U.S. arm of Hoechst A.G.—is increasing its spending. American Hoechst will boost spending to about $118 million, about 18% above the company's spending for plant and equipment in the U.S. this year.

BASF and the U.S. subsidiaries of Bayer will hold their spending at 1981 levels next year. BASF North America includes BASF Wyandotte and Badische Corp.

The U.S. subsidiaries of Bayer present the worst case for 1982 of the three major West German firms. Spending at Bayer's U.S. subsidiaries—Mobay, Miles Laboratories, and Cutter Laboratories—will drop 27% in 1982 to about $155 million from $248 million spent on capital equipment in 1981. This year, Mobay and the other Bayer subsidiaries were the only ones in the group to increase capital spending—up 21% from 1980 levels. The decrease at Mobay and the other Bayer subsidiaries next year comes because they are ending a three-year investment cycle.

For the past few years, the rate of spending by the West German firms generally had been been increasing, although the average annual rate of change was slowing.

William Storck, New York

U.S. subsidiary (parent)	Capital spending in U.S. ($ millions): 1982[a]	1981	1980	1979	1978	Change 1981-82	Average annual change 1978-81
American Hoechst (Hoechst)	$118	$100	$100	$189	$105	18%	−2%
BASF North American (BASF)	200	200	200	136	118	0	19
Mobay and other subsidiaries (Bayer)	155	248	220	150	119	−27	9

a C&EN estimate.

reason for its reduced capital budget in 1981 and 1982 is a change in priorities for investment. Dow is lowering somewhat the emphasis on capital-intensive basic chemical plants worldwide and increasing the emphasis on less capital-intensive downstream specialties. This shift naturally follows the company's decision to make specialties (formally called "end products and services") half its total profits in 1990 compared to just 20% in 1978 (C&EN, Nov. 23, page 10).

As a result, Dow no longer leads the pack in chemical investment after greatly exceeding other companies' spending through the late 1970's. From a high point of $1.3 billion in 1979, Dow steadily has reduced its spending to $1.2 billion in 1980, $1.1 billion in 1981, and $1.0 billion estimated for 1982.

In both 1981 and 1982, Dow will come in third for the 17 companies in C&EN's survey behind Du Pont and Union Carbide. Both Du Pont (excluding Conoco) and Union Carbide have made major increases in capital funds since 1978. Du Pont has lifted its capital budget from $714 million that year to $1.4 billion estimated for 1982. Carbide has picked up its spending from $688 million in 1978 to an estimated $1.3 billion in 1982.

Although Du Pont and Carbide have stuck close to planned spending targets in 1981, the industry as a whole has not. Downward economic pressures have brought about a 7% shortfall from original plans for the combined 17 companies. Nine of the group actually cut spending from 1980, although only three had planned to do so.

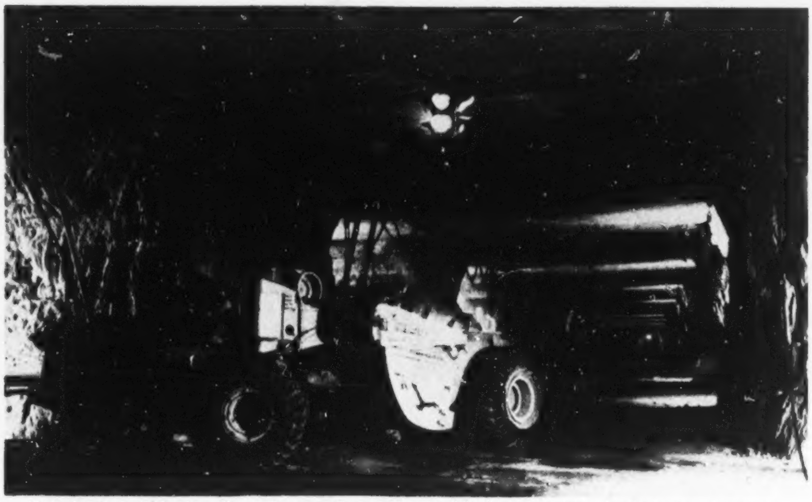
Such performance in 1981 puts a caution into industry's estimates for spending in 1982. Again, just two companies (Dow and Stauffer Chemical) say they will reduce spending from 1981. But capital spending plans have a way of tilting toward the direction of the business cycle even though companies try to plan for conditions two to three years away.

For engineering companies and equipment suppliers, the relaxed state of chemical plant funding is not good news for 1982. But the truth is, although the chemical industry has the money to spend, it doesn't see the need for at least another year. □

PPG turns mine into waste disposal site

PPG Industries plans to convert its worked-out limestone mine at Norton, Ohio, to a storage facility for chemical wastes. A Pittsburgh-based consulting firm has termed the site, near Akron, "ideal." And, at a planned rate of 50,000 tons per year of waste to be stored, it is large enough to give the company nearly 200 years of storage capacity. PPG expects about 20% of the waste to come from company plants around the country, and the rest to come fron non-PPG plants handled on a contract basis.

The company, which is putting together its application to submit to the Environmental Protection Agency for licensing under the provisions of the Resource Conservation & Recovery Act, will not handle nuclear or radioactive wastes. Nor does it plan to handle wastes with a high vapor pressure—for example, gasoline and paint thinner. That will virtually exclude, PPG says, materials labeled flammable.



Worked-out Norton limestone mine will provide huge amount of storage space

According to Robert E. Widing, vice president of PPG's agricultural and performance chemicals division, the site "is no ordinary mine." The cavern is a series of roughly four-story-high rooms, carved out of rock nearly one half mile underground. The mine is dry, avoiding potential rust problems, and there are no connections to the surface except for personnel and production shafts. Those conditions, and the presence of a 1500-foot cap of shale overhead, led D'Appolonia Consulting Engineers to conclude that the site "not only was uniquely suited for chemical waste storage but also would provide the highest degree of protection for the environment and public health that such a facility could have." The mine "is simply too deep" to contaminate surface water, points out Phillip Antommaria, an engineer with D'Appolonia.

Under PPG's plans, the company will build a special access road to the site, and build a closed, all-weather unloading station. Containerized materials to be disposed of will be stored in the rooms making up the 300 million cu ft of mine dug out while it was being worked, from 1942 to 1976, for soda-ash raw materials. After each room is filled, it will be sealed with a concrete or cinder-block wall.

The idea of using worked-out mines for storing chemical wastes is not new, but it is new to the U.S. West Germany's Kali & Salz, for example, uses its old mines for disposal. However, PPG hopes to avoid the storm of controversy that erupted when Kali agreed three years ago to store arsenic wastes and Kepone for Allied Chemical (C&EN, July 31, 1978, page 7).

Instead, PPG is emphasizing community relations. Before it made any announcements to the press, company officials met with the mayor and other leading citizens of Norton to inform them of the plan and ask their help and cooperation. For example, the mayor was requested to appoint an advisory committee that will have a chance to review the information the company uses in its permit applications. And it informed its employee-union representatives, company employees, and regulatory-agency officials of the plan before its press conference earlier this month. "We wanted to do this in an intelligent and sensitive way," a PPG staffer says, to answer local community concerns. □

NEWS

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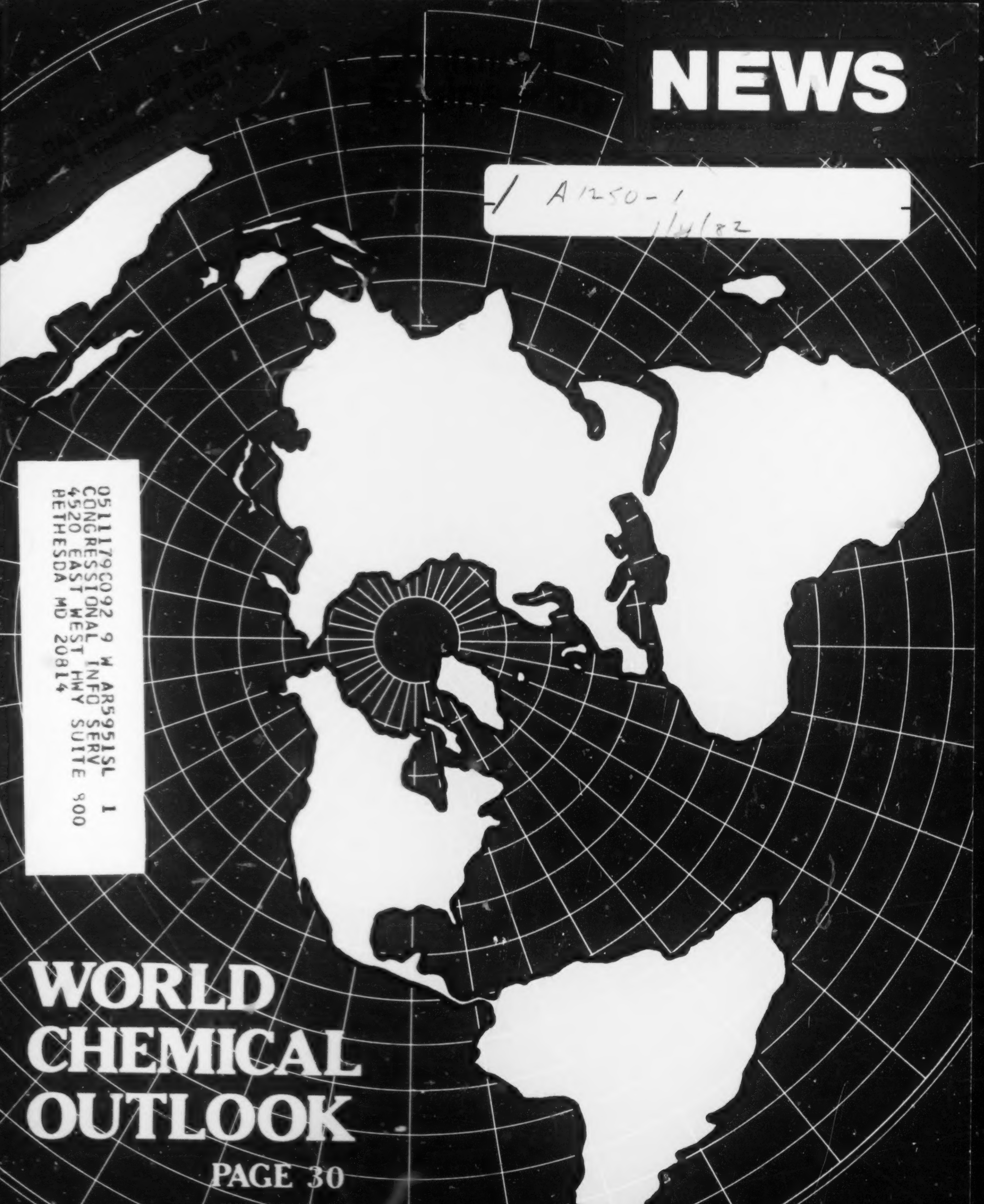

WORLD CHEMICAL OUTLOOK

PAGE 30

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Chemical & Engineering NEWS

4 Letters
5 Editor's Page

Concentrates

10 Business
16 Government
22 Science/Technology

The Departments

54 ACS Comment
82 Newscripts

News of the Week

- ***Most federal agency R&D budgets reduced*** *in latest continuing resolution, with exception of Defense Department.* ***Page 6***
- ***Arkansas law requiring the teaching of creationism*** *in public schools likely will be struck down this week.* ***Page 6***
- ***Soviet decision to yield to Andrei Sakharov*** *and his wife in their hunger strike seen as unprecedented concession.* ***Page 7***
- ***Du Pont workers reject United Steelworkers of America*** *in elections at 14 of the chemical company's plants.* ***Page 8***
- ***Stable solid containing a silicon-silicon double bond*** *has been synthesized by chemists at Wisconsin and Utah.* ***Page 8***
- ***Demand for engineering graduates*** *will remain strong in 1982 and starting salaries will continue to rise.* ***Page 9***
- ***Avon Products and Mallinckrodt will merge,*** *resulting in diversification for Avon and capital for Mallinckrodt.* ***Page 9***

Business

- ***Plastics face global changes*** *in the rest of the decade as demand, capacity, and prices rise but profits fall.* ***Page 13***

Government

- ***New program to crack down on illegal dumping of wastes*** *begins at Environmental Protection Agency.* ***Page 21***

Science

- ***Blood-brain barrier*** *can be penetrated by new methods that alter barrier itself or let chemically modified drugs enter brain where they are restored to active form.* ***Page 24***
- ***Revised guidelines for recombinant DNA research*** *are published and public reaction is being sought.* ***Page 25***

Education

- ***MIT and Whitehead Institute for Biomedical Research*** *agree to set up a research partnership after months of debate over the collaboration.* ***Page 26***

Technology

- ***1981 Chem Show*** *unveils new process equipment: exhibitors this year showed a wide range of equipment for waste incineration and materials recovery.* ***Page 27***

World Chemical Outlook

World's chemical economy *faces a year in which growth will be slight or nonexistent as worldwide business recession undercuts demand and forces producers to restructure operations.* ***Page 30***

Meetings

- ***C&EN's Calendar of Events*** *lists scientific meetings and other events of chemical interest in 1982.* ***Page 56***

Major global changes ahead for plastics

Demand, capacity, and prices will rise, but competition will lower profits, trigger shakeout of producers in major industrial countries

Bruce F. Greek
C&EN, Houston

Some dramatic changes are in store globally in the remainder of this decade for plastics makers. Besides the expected upward changes in production, capacity, and prices, it's likely that real profitability will decline as will the number of producers in major industrial countries and exports from all industrial countries. These were some of the conclusions at a conference on International Plastics Outlook: Markets and Issues, held in New York City earlier this month.

Other changes discussed will be new technologies, much more interpolymer competition, new pricing methodology, and marketing of more fabricated forms by polymer producers. Some of these changes will be in areas seen only dimly now. They might be as unexpected as was the commercialization of linear low-density polyethylene when the decade of the 1970's opened.

Specific conclusions at the conference dwelt more on individual polymer problems and opportunities, which, as expected, will vary widely in different countries. For example, the current worldwide overcapacity in most major volume plastics will last well into the 1980's, forecasts Robert J. Bauman of Chem Systems. However, polypropylene producers will be the most fortunate of polymer makers. By 1985, worldwide demand for polypropylene will exceed expected operable capacity by a small amount. This will be in sharp contrast with the current situation when 1980 demand for the polymer accounted for 77% of effective capacity. Present effective capacity is estimated at 90% of nameplate capacity of nearly 6.5 million metric tons.

Of the other major-volume plastics, polystyrene appears to have the most difficult future, Bauman says. Even as demand for polystyrene rises at a bit more than 5% annually, capacity also will continue to rise, based on estimates of reports of construction plans. Overcapacity will exist throughout this decade. This overcapacity and noncompetitive costs of production in some areas of the world in contrast with other areas will lead to more shutdowns of polystyrene capacity during the decade.

Polyethylene of all kinds might just squeak through at the end of this decade in a balanced position in spite of some current problems in the marketplace that may continue through much of the 1980's, according to Bauman's current forecasts. Demand for low-density and linear low-density polyethylene will grow from about 10 million metric tons in 1980 to 16.4 million metric tons in 1990, at a rate averaging almost 5% per year. But at the same time, capacity will grow from 13 million metric tons to 20 million metric tons per year. This then means that in 1990 there will be about 2 million metric tons of excess capacity assuming an effective average operability of 90% of nameplate capacity.

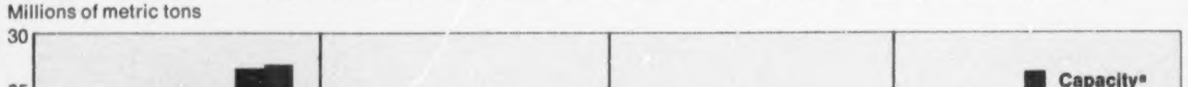
Normal alpha olefins will ride boom in polyolefins use

	Demand in North America			Average cumulative growth rate	
Millions of lb	1980	1985	1990	1980–85	1980–90
C_4	72	239	609	27%	24%
C_6	21	33	50	9	9
C_8	29	84	230	24	23
TOTAL	122	356	889	24%	22%

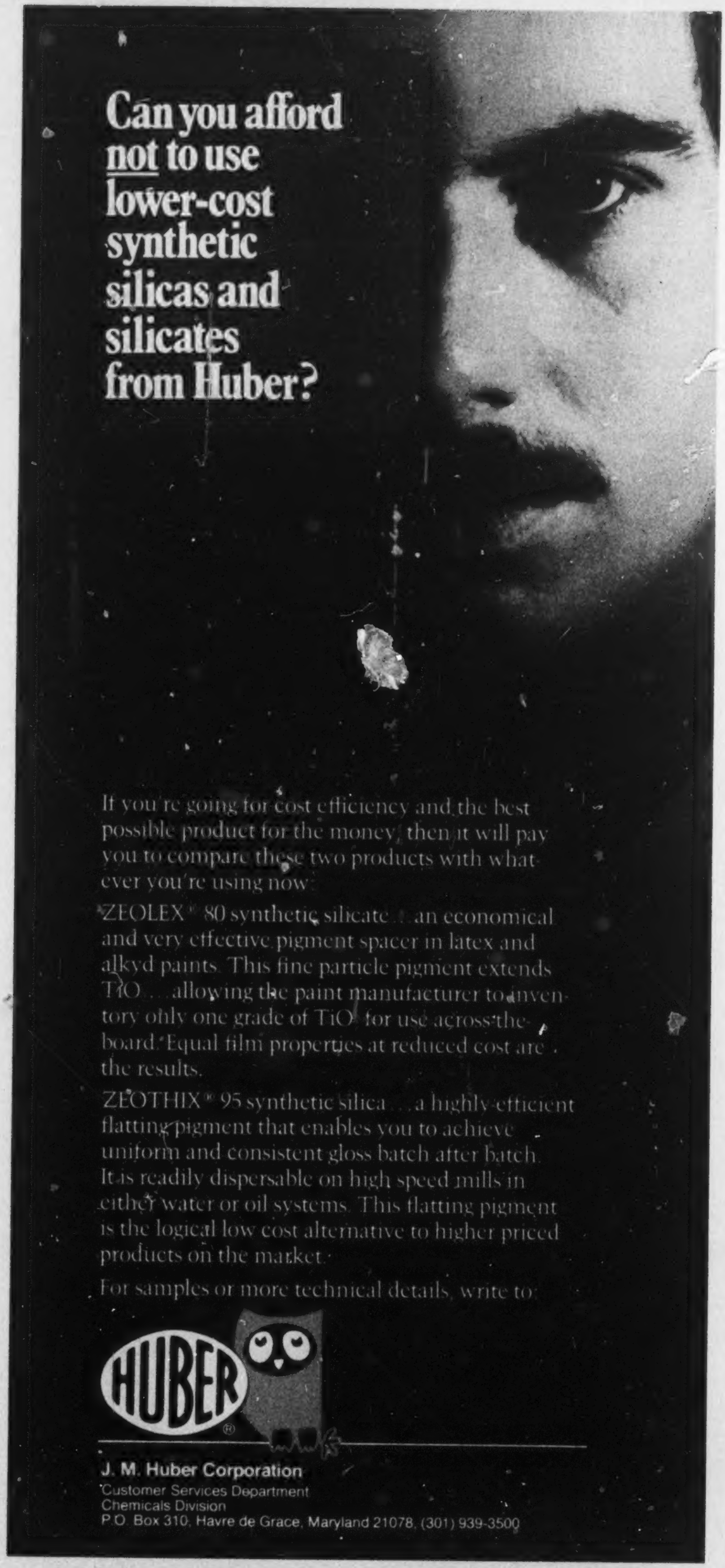
Source: Gulf Oil Chemicals

Much new capacity for low-density (mostly linear) polyethylene built in Canada, the Middle East, Asia, and South America will be in excess of their domestic demands. This resin can be expected to flow out of these

Global demand for major plastics may take until 1990 or later to catch up with capacity



a 90% of nameplate. b High-, low-, and linear low-density types. Source: Chem Systems



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countries at prices lower than those of the traditional exporters, such as Western Europe, Japan, and the U.S.

Use of high-density polyethylene will grow at a faster rate during this decade—more than 8%—than low density, Bauman forecasts. This growth could cause demand to exceed capacity as early as 1985. But this is not likely because most producers either have or will have capability to make linear low-density in high-density plants and the reverse.

Therefore, Bauman points out, all of the various kinds of polyethylene must be considered. For this reason, polyethylene producers will do well to have a balance between supply and demand at the end of the 1980's. In short, he indicates that the outlook for the total polyethylene business through most of this decade is not very favorable.

Supply of polyvinyl chloride, now considered the resin in most trouble in the U.S., might become tight late in this decade. This presumes that new capacity additions in the world remain at low levels—2.9% annually over the decade and a demand growth of 5.8% annually. But during the first half of the 1980's overcapacity will be large.

The overcapacity problem could be heightened for some time, too, as the feedstock supply shifts from U.S.-made to imported ethylene dichloride, a result of changing energy and hydrocarbon costs in different parts of the world. Bauman suspects that ethylene dichloride could become one of the more widely traded commodities of the 1980's.

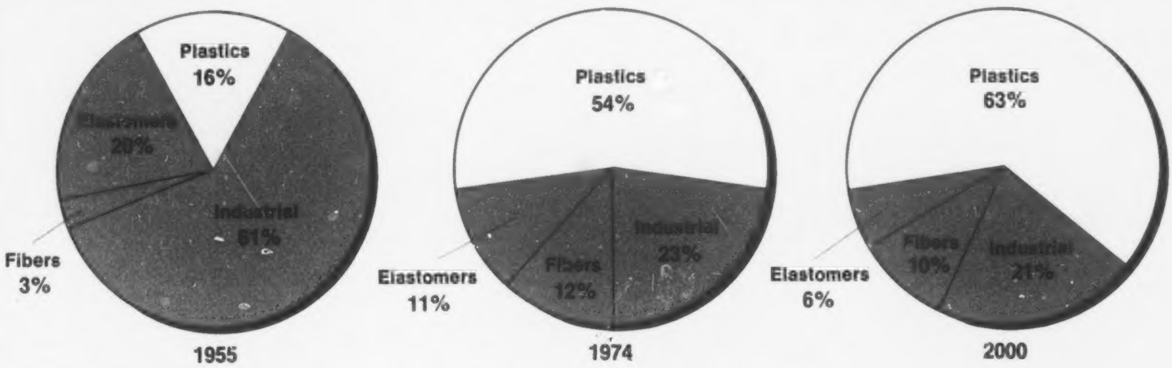
Turning to some specific areas of the world, Latin America's plastics industry will have a growth second only to that of the Middle East. Latin America's industrial plastics output likely will increase 250% over the next 10 years, according to Robert Albert of Dow Chemical. Most of the growth will be in the countries with oil and gas resources such as Mexico, Venezuela, Colombia, Brazil, and Argentina, with plastics industries in Ecuador, Peru, and possibly Guatemala developing late in this century.

By the year 2000, Latin American plastics output will be some 6 million metric tons or a fifth of production in developing countries of the world. Total production then should be almost 198 million metric tons.

Japan's plastics industry faces much the same problems as are faced in the U.S. and Europe, according to M. (Jack) Mizoguchi of Mitsubishi Rayon. Low-density polyethylene, for

Plastics' share of Latin American petrochemicals will continue to climb markedly

Petrochemical uses, %



Source: Dow Chemical Latin America

example, will have a low domestic demand growth of 1 to 2%, following a decline in production in 1980 from a peak of nearly 1.4 million metric tons in 1979. Higher crude prices forced up prices of low-density polyethylene, which restricted demand and prompted consumers to look for substitute materials.

The Japanese plastics industry currently is building plants for production of linear low-density polyethylene, according to Mizoguchi. He forecasts that linear low-density material will replace conventional high pressure-process, low-density polyethylene at a pace similar to that of the U.S. and Europe.

In other areas of polyethylene development, thinner films to reduce costs in packaging are coming. Technologists are working to develop higher strength grades, laminated films, and greater use of high-density polyethylene.

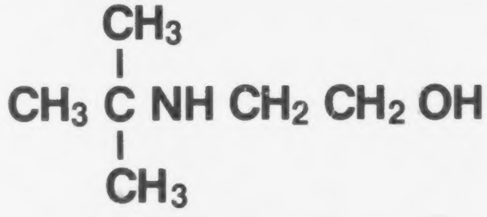
Raw materials for making plastics are not expected to be a problem during this decade, several speakers indicated. Supply of propylene might become tight temporarily, limiting polypropylene's growth.

Ethylene consumption in making polyethylene will continue to rise as a share of total consumption in the U.S., according to Arnold J. Cahill of Gulf Oil Chemicals. He puts the share to be consumed by polyethylenes at 49.4% of the total in 1985, up from 46.5% in 1981. By the 1985–86 period, U.S. ethylene capacity probably will be used at the maximum effective rate, assuming an improving inflation picture and stable energy prices.

One of the lesser known, but faster growing, uses of ethylene is in making the alpha olefins used as comonomers with various polyethylenes and polybutene-1. Demand for these olefins—1-butene, 1-hexene, and 1-octene—will grow an average of about 20% per year during this decade, Cahill says. Admittedly, the base is small, an estimated use of 122 million lb for all olefins in 1980 in North America, but consumption will reach nearly 900 million lb in 1990.

Besides polybutene, the linear low-density polyethylenes and high-density polyethylene are behind this growth. Union Carbide's linear low material uses 1-butene and Dow Chemical's 1-octene. Some film grades of these polyethylenes require as much as 19% of these comonomer alpha olefins. □

Try tertiary-Butylaminoethanol.



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WORLD CHEMICAL OUTLOOK

Gloom is pervasive among chemical producers throughout much of the industrialized world as 1981 draws to a close. Just about wherever you look, output of chemicals is being curtailed, plants are operating well below capacity, and return on investment is being squeezed under the twin impacts of recession-dampened demand and upward spiraling operating costs.

The U.S. chemical industry, which just a year ago was pulling itself out of a brief but painful slump, now finds itself sliding again into a period of disarray. Production has been unable to maintain any sustainable growth in the past two years. Industry executives are hopeful—but by no means certain—that next year's second half will bring relief.

Chemical firms in Western Europe, grappling with chronic excess capacity, weak prices, and heavy losses in many major product areas, are striving to adapt to the frigid business climate by drastically trimming and restructuring their operations. The chemical industry that emerges there in the next couple of years may be much changed from that in place during the 1970's. Meanwhile, growth has slowed in the state-controlled chemical industries of Eastern Europe and output frequently is falling short of targets.

Japan's chemical industry, too, is troubled by the high cost of feedstocks, a decline in vital exports, and stiffer competition from low-cost imports at a time when its home market is slack. And Canadian companies, likewise hard-pressed by a cost/price squeeze and dwindling demand at home, are pushing harder for exports, especially to sop up the output from the big petrochemical plants now under construction in gas-rich Alberta.

United States 32
Foreign Trade 35
Western Europe 38
Japan 42
Canada 45
U.S.S.R./Eastern Europe 47
China 49
Middle East 51
Other Areas 52

United States

Chemical output is sliding following a short-lived recovery

Although a new recession is forcing a cutback now, chemical producers hope for a strong rebound in 1982's second half

David M. Kiefer, C&EN Washington

That 1981 is going into the record as a recession year for the U.S. economy is really no surprise. A year ago, economic forecasters were contending that this year would witness several months of stagnation at best and that a mild decline in business activity was even more likely.

But that the year actually would be ending with the economy in the throes of a steep slump of still uncertain depth and duration definitely is not what the analysts were looking for. The standard scenario then was that business conditions during the first half of the year would be unsettled but that a strong rebound was in the cards during the second half. By the end of 1981, the seers avowed, industrial production would be rising smartly, unemployment would be shrinking, and the national economy in general would be more robust than at any time in the previous two years or more.

But it hasn't worked out that way—not by a long shot. As 1981 winds down, industrial production is being cut back drastically right across the board. New orders for manufactured goods plummeted 5% in October, for the third consecutive monthly decrease. Unemployment rose to 8.4% of the labor force in November, the highest level since 1975, and is expected to move to 9% or above during early 1982, which could push it higher than at any time since before World War II. And the consensus of economic forecasts points to a decline in real gross national product both during the current quarter and the first quarter of 1982, at least, following a very slim increase for 1981's third quarter.

In many ways, moreover, it's a peculiar recession that is now under way. For one thing, it follows hard on the heels of the 1980 recession; the business rebound of barely one-year duration from the trough of mid-1980 was the shortest such recovery of the postwar years. The recovery, in addition, was neither strong nor hardly ever complete. Industrial production, for example, never really worked its way above its pre-1980 peak before it started to ease off at the end of last summer. Unemployment never fell below an unsatisfactory 7% of the work force. The bellwether automobile and building industries remained deeply depressed throughout the recovery period. The current business dive, consequently, has taken off from a relatively low springboard.

Chemical producers, too, barely recovered from the 1980 decline in their operations. Production of chemicals and allied products (including drugs, detergents, coatings, and agricultural chemicals) climbed nearly 16% during the five months immediately following its recession low in July 1980, then remained practically unchanged throughout the first eight months of 1981 at about the same level it had been prior to the 1980 downturn. Output of chemicals and synthetic materials (plastics, man-made fibers, and synthetic rubber) alone increased 26% during the same five-month recovery period, but it, too, never moved appreciably above its prerecession peak at the start of 1980. In fact, the only group of basic chemicals that were being produced in significantly greater volume early this year than before last year's recession were fertilizer raw materials such as ammonia and other nitrogen products.

Then as industrial production as a whole began to falter at the end of last summer, output of chemicals also started to dwindle. Although it is still too early to track the decline quantitatively, C&EN estimates that production of chemicals and synthetics probably has fallen about 10 to 12% since last July and now is nearly 15% lower than it was 12 months ago. As a result, production for all of 1981 probably will surpass 1980's results only 3 to 5%, after having been 8% ahead of last year at the end of August.

How much further down the current slide has to run is by no means clear; turning points in a business cycle are notoriously difficult to foresee. Output of chemicals and synthetics fell 22% during the first half of last year. In the previous 1974–75 recession, the drop was almost 30%, also in just about half a year. Many economists now are convinced that the national economy will hit bottom during the first half of 1982—probably about the end of the first quarter. If that indeed should be the case, output of chemicals is likely to decline between 15 and 20%, pretty much mirroring what happened during 1980.

The key to recovery, of course, lies not so much with what happens in the chemical industry itself as with a return to health on the part of the major customers for chemicals in other hard-hit industries. Much of the blame for the current economic malaise rests on tight credit and the high cost of borrowed money during the past year or so, which in turn reflects government efforts to stem inflation. Soaring interest rates have clamped a lid on demand for major consumer purchases, most notably new homes and automobiles. And now the spreading recession has further sapped consumers' confidence, so that both these critical markets for such chemical materials as plastics, fibers, paint, and rubber are in greater disarray than ever.

Housing starts, for example, have been slumping all year and plunged this fall to the lowest level in 15 years. Recovery is not yet in sight. Total housing starts this year probably will be no more than 1.1 million units, roughly 15% fewer than last year's disappointing 1.3 million units and barely half the number started in either 1977 or 1978.

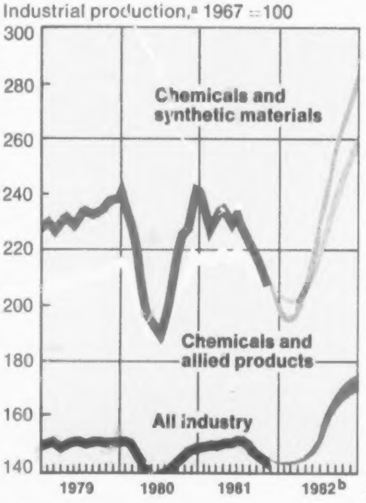
Although home mortgage rates, like other interest rates, have started to ease a bit in the past few weeks, housing experts don't expect them to fall to a manageable range of 14 to 15% much before midyear, if then. Consequently, demand for new housing is expected to remain soft well into 1982.

Conditions in the automobile industry now are no less dismal. The industry's high hopes for its 1982 models have gone aglimmering. (The 6.6 million cars built during the 1981 model year was the lowest number in six years.) Car sales sank in October and November to the lowest rate in 22 years. For all of 1981, auto sales probably will not quite match 1980's 8.9 million units, as high credit costs and high sticker prices take their toll. U.S. production, too, will lag 1980's 6.4 million units. With well over 200,000 auto workers laid off indefinitely, the auto industry, like the housing industry, is bucking two abysmal years back to back.

Detroit, moreover, is not looking for any meaningful recovery in the near future. Car makers have cut back their estimates for sales next year to between 9 million and 10 million units, with most forecasts bunched near the low end of that range.

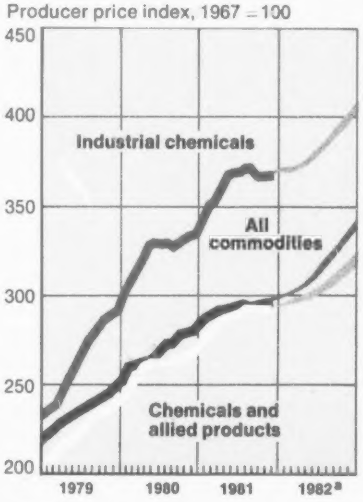
Although housing and autos are the most visible areas of weakness, in the past couple of months recession has spread much more widely through the U.S. economy. Low home sales and high credit costs have undercut the lumber industry and led to lower consumer demand for furniture, appliances, and other home furnishings. Weak demand for automobiles has forced cutbacks in steel and aluminum production. Output of aluminum, for example, has fallen about

Output will recover during next year's second half . . .



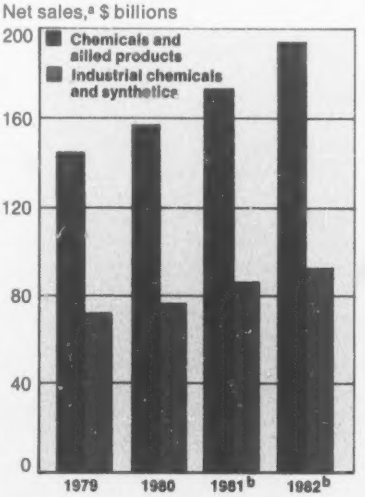
a Seasonally adjusted. b C&EN estimates.
Source: Federal Reserve Board

. . . spurring increases in selling prices again . . .



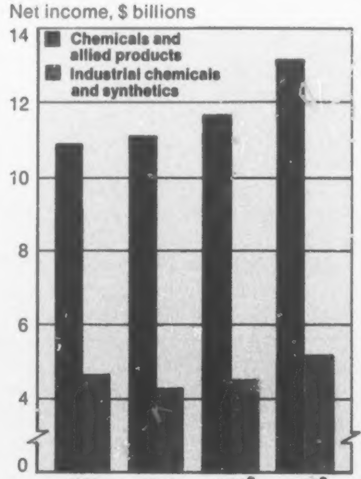
a C&EN estimates.
Source: Bureau of Labor Statistics

. . . boosting chemical producers' sales . . .



a Excludes sales of foreign subsidiaries. b C&EN estimates. **Source:** Federal Trade Commission

. . . and lifting their profits to a record level



a C&EN estimates.
Source: Federal Trade Commission

Modest growth ahead for production of chemicals after a standoff in 1981

	1982	1981	1980	1979
INORGANIC CHEMICALS				
Thousands of tons unless otherwise indicated				
Ammonia	19,600	19,200	19,044	18,523
Chlorine gas	11,200	10,700	11,190	12,228
Hydrochloric acid	2,700	2,500	2,752	3,090
Nitric acid	9,400	9,000	8,733	8,465
Oxygen, billions of cu ft	440	425	415	457
Phosphoric acid	11,000	10,300	10,856	10,317
Sodium hydroxide	11,400	10,900	11,311	12,772
Sulfuric acid	44,300	42,500	44,273	43,118
ORGANIC CHEMICALS				
Millions of lb unless otherwise indicated				
Acetic acid	2,850	2,750	2,977	3,265
Acetone	2,200	2,050	2,076	2,653
Acrylonitrile	2,050	1,900	1,830	2,018
Benzene, millions of gal	1,550	1,450	1,585	1,673
Butadiene	3,200	2,900	2,799	3,583
Cumene	3.750	3,600	3,459	3,917
Cyclohexane	1,950	1,875	1,964	2,425
Ethylene	30,500	28,500	28,667	29,904
Ethylene glycol	4,300	4,000	4,386	4,729
Formaldehyde	6,000	5,700	5,555	5,971
Methanol	8,500	8,000	7,153	7,367
Phenol	2,800	2,650	2,568	2,981
Phthalic anhydride	950	840	818	1,013
Propylene	14,900	14,100	13,657	14,198
Styrene	7,100	6,600	6,856	7,484
Toluene, millions of gal	1,050	930	1,017	1,010
***o*-Xylene**	1,020	940	985	1,082
***p*-Xylene**	4,400	4,050	4,238	4,650
PLASTICS				
Millions of lb				
Polyethylene, high density	4,950	4,600	4,405	5,010
Polyethylene, low density	8,000	7,600	7,291	7,793
Polypropylene	4,200	3,900	3,648	3,841
Polystyrene	3,900	3,600	3,521	4,005
Polyvinyl chloride	6,100	5,800	5,470	6,119
SYNTHETIC FIBERS				
Millions of lb				
Acrylic and modacrylic	740	690	779	761
Nylon	2,600	2,450	2,358	2,720
Olefin and vinyon	825	775	748	759
Polyester	4,350	4,200	3,989	4,178

Sources: Bureau of the Census, International Trade Commission, Society of the Plastics Industry, Textile Economics Bureau, C&EN estimates (for 1981 and 1982)

19% since last March and is likely to be 4% lower this year than in 1981. Bumper crops and slack demand, especially in export markets, have depressed prices for agricultural products and slashed farmers' income for the second year in a row to the lowest level since 1977. And next year is not expected to bring any marked relief. One result is a sharply curtailed demand for farm equipment.

All these developments spell deep trouble for the chemical industry in the next few months. Reduced farm income and weak demand abroad have cut into fertilizer sales, for one thing, with phosphate products especially hard hit. Production of phosphate products was down 20% from a year earlier for the four months through last October, and phosphate rock inventories have swelled to an all-time high.

Weakness in housing and automobiles has spilled over into plastics production, which has been trending downward since last March. Total output this year will be higher than in 1980, largely because the first half of 1981 came on strong. But output this year will not match that of 1979; output next year may not do so either. Increased capacity, meanwhile, has thwarted attempts by producers to hike selling prices into line with rising production costs.

After a relatively strong first half, synthetic fibers also are in a sharp slump. Shipments of man-made fibers were down 9% during the third quarter from the previous three-month period and have declined further since then. Production also was lower in the third quarter than during the second quarter and is being cut back further as the year ends. Industry executives look for reduced demand and low levels of output well into the first half of 1982.

Further aggravating the business climate for U.S. chemical producers is the poor state of business overseas. Western Europe's recession, coupled with the strength of the U.S. dollar, has curtailed demand for U.S. exports and eroded the profitability of foreign subsidiaries.

Even the typically recession-proof pharmaceutical sector of the U.S. chemical industry is taking its lumps this year. Profits are likely to be surprisingly lower than in 1980 for U.S. drug makers, in part because of currency exchange losses on operations abroad. However, the Financial Accounting Standards Board recently revised its rules for accounting for currency fluctuations so as, in effect, to isolate gains or losses from reported earnings. The new rules are likely to improve the financial results next year for both drug and chemical companies with a big stake in foreign countries.

If, as most economic prognosticators now predict, the current recession, no matter how sharp, is relatively brief, 1982 as a whole may not be a total loss for the chemical industry. Interest rates now seem to be declining, and after two or more years of slack sales for new homes, automobiles, and other big outlets for chemicals, a pent-up demand probably is waiting to be tapped. C&EN estimates, in fact, that business will start to pick up again for the chemical industry during next year's second quarter. By the end of next summer, production probably will be running at least as high as it was early this year and at year's end it could well be a third higher than it is now.

Prices, too, after weakness during the early part of 1982, probably will be strengthening again during the second half of the year. As a result, after a relatively dreary first half, both sales and profits are likely to be riding high as 1982 closes. Earnings for industrial chemical producers in 1982, for example, are expected by many industry analysts to top this year's mark perhaps 10 to 15%. □

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Foreign Trade

Growth slows dramatically for U.S. exports of chemicals

U.S. trade surplus in chemicals will shrink this year for the first time in nine years as overseas demand weakens

Earl V. Anderson, C&EN New York

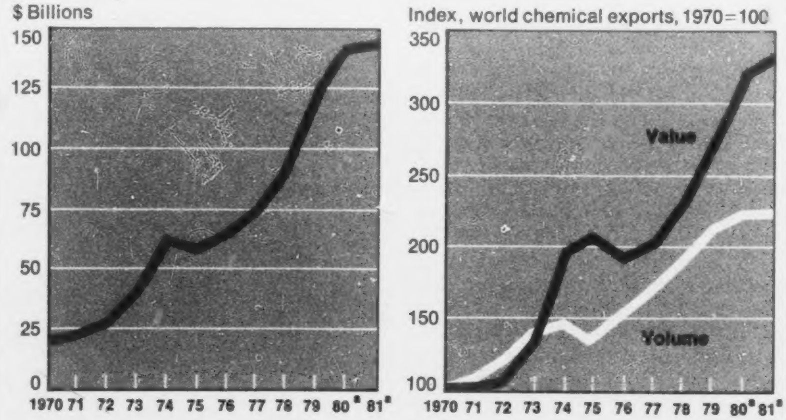
The high-flying growth in world trade that everyone had become accustomed to during the 1970's and almost had come to take for granted is slowing down.

The Organization for Economic Cooperation & Development says so. The International Monetary Fund says so. The General Agreement on Tariffs & Trade says so. And businessmen who depend upon trade for their livelihood know that it's so.

In fact, world trade actually may decline this year. Not just in volume. Not just in constant dollars. But even in inflated dollars.

World chemical export growth looks dramatic . . .

. . . but the key is price, not volume



a C&EN estimates. **Source:** United Nations

Last year, world trade (measured only as exports) became a $2 trillion economy in its own right. This year, it will be lucky—very lucky—to top that. More than likely, it will slide backward slightly to about $1.9 trillion. And that's in 1981 dollars.

It's no secret that the deep economic slump that is so widespread among industrialized countries is starting to put a strain on exporters. In developing countries, which are blossoming into increasingly important export markets for the developed nations, the situation is no better.

In the nonoil-producing developing nations especially, mounting costs of imported oil are raising havoc with international accounts. To compensate, they are cutting back on other imports, which means fewer exports for industrialized nations such as the U.S.

Other forces also are putting a crimp in world trade. Many countries have learned the hard lesson of energy conservation. This has kept the worldwide flow of oil lower than it otherwise would be and tends to keep the overall trade figures down.

But oil alone won't account for the trend. The United Nations' index of manufactured goods exports for the first half of 1981 shows no growth at all. The basic reason is the poor economic climate in most of the world. Not only has demand for imported products dropped, but free traders in good times become protectionists in bad times.

There's ample evidence that protectionism is on the rise, despite the accomplishments of the Tokyo round of multilateral trade negotiations.

For the U.S. chemical industry, whose exports have enjoyed unprecedented growth during the past few years, the impact of all this is apparent. U.S. chemical exports this year probably will hit $21.2 billion—a remarkably high figure considering that exports of chemicals totaled less than $10 billion only five years ago.

Still, $21.2 billion represents only a 2.2% increase over last year, compared to the 20% and 37% increases of the previous two years. Obviously, the advantage in low-cost feedstocks that recently worked so well in their favor isn't helping U.S. chemical exporters overcome the handicaps of weak demand in overseas markets and a strong dollar that makes U.S. products more expensive overseas.

One notable exception is Japan, where mounting U.S. chemical exports are becoming a thorn in the side of troubled Japanese chemical companies. U.S. chemical exports to Japan will increase about 15% this year, to $2.3 billion and, in a reversal of roles, the Japanese are starting to complain about import competition. So much so that an industry-government team from Japan is scheduled to hold a series of meetings with their U.S. counterparts to discuss the problem.

The only other notable growth area for U.S. chemical exports this year will be Canada, which many U.S.

companies consider a natural extension of their domestic market. Shipments to Canada should be up 17% in 1981 to $2.5 billion. But Canada is developing its own world-scale petrochemical industry based on inexpensive natural gas, primarily in Alberta, so that U.S. companies may not be able to rely on a sure-fire growth market there much longer.

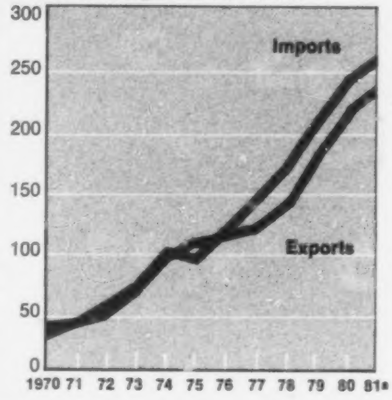
In other major chemical export markets, it's been downhill all the way this year for U.S. chemical companies. Shipments to western Europe, as a single bloc the largest export market for U.S. chemicals, are off about 5%.

In developing countries, the situation is no better. These areas have become, collectively, an important outlet for U.S. chemicals and now account for about 40% of total chemical exports. But this year, exports to the two most critical areas, Latin America and Asia (excluding Japan), will be down 4% and 5%, respectively.

On the other side of the trade coin, U.S. imports of chemicals are growing faster this year—much faster than exports. One reason is that the U.S. economy throughout the early part of the year was in better shape than many European economies. That tends to encourage imports, although the impetus diminished during the latter part of the year. Another is that, just as a strong dollar makes exports more expensive, it makes imports less expensive.

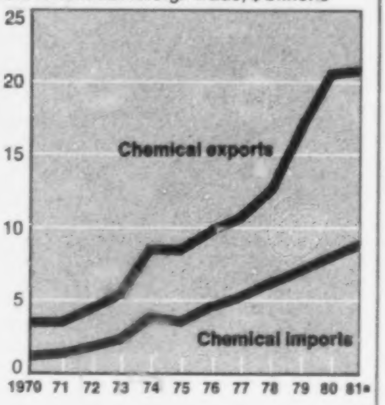
U.S. trade deficit widens again . . .

Total U.S. foreign trade, $ billions



. . . and chemical trade surplus shows a rare drop

U.S. chemical foreign trade, $ billions



a C&EN estimates. Source: Bureau of the Census

Exports decline to some foreign markets for U.S. chemicals

$ Millions	1981a	1980
U.S. CHEMICAL EXPORTS		
Canada	$ 2,502	$ 2,134
Western Europe	6,106	6,429
Eastern Europe	297	88
Japan	2,268	1,964
Communist Asia	360	386
Middle East	530	459
Rest of Asia	2,629	2,782
Latin America	4,643	4,846
Australasia	763	645
Africa	636	721
Other	466	286
TOTAL	**$21,200**	**$20,740**
U.S. CHEMICAL IMPORTS		
Canada	$2,986	$2,494
Western Europe	3,974	3,953
Eastern Europe	115	195
Japan	970	697
Communist Asia	125	107
Middle East	96	58
Rest of Asia	192	163
Latin America	691	536
Australasia	192	206
Africa	125	62
Other	134	112
TOTAL	**$9,600**	**$8,583**

a C&EN estimate. **Source:** Bureau of the Census

As a result, U.S. chemical imports are likely to jump almost 18% in 1981 to a record $9.6 billion. And the envied U.S. chemical trade surplus will drop from last year's $12.1 billion to $11.6 billion—the first drop in nine long years.

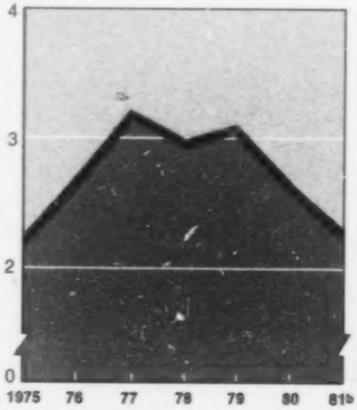
Do the discouraging events of 1981 signal the start of a long-term downtrend for the fortunes of U.S. chemical exports? Not necessarily.

The industry can do nothing about economic conditions throughout the world, which in large measure dictate the flow of world trade. But there are other potential problems on the horizon:

- Competition is increasing from new chemical producers with low-cost feedstocks in Canada, Mexico, and the Middle East.
- There is growing government-owned competition on the chemical trade scene. Many foreign companies, either partly or entirely controlled by their governments, do business with a different objective in mind than that of private corporations. Often, these companies willingly sacrifice profits to achieve such goals as creating employment or even enhancing prestige.
- Protectionism is increasing. Although the last round of multilateral trade negotiations took the sting out of tariffs and supposedly slapped controls on nontariff barriers, some countries still haven't put the agree-

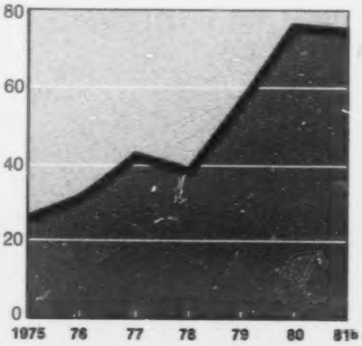
U.S. imports of oil are falling . . .

Billions of bbla



. . . but their cost remains high

$ Billionsa



a All petroleum products. b C&EN estimate. **Source:** Bureau of the Census ments into practice. Protectionism also is being practiced in new, more sophisticated forms, under the guise of national economic policies.

These represent handicaps for U.S. chemical exports. But the industry has some aces up its sleeve.

The U.S. still remains the largest single integrated chemical market in the world. Because of that, U.S. chemical companies have been able to build large plants that have an inherent economy of scale.

U.S. chemical management is as good as any in the world. And the industry's strong technological base enables it to develop high-technology, higher value-added products.

This is important and will become more important as new competition neutralizes the industry's feedstock advantage. Chemical products flow from one country to another for a variety of reasons. But the fact that one country has a proprietary product that no other country has is one of the biggest. About one third of all chemical exports, according to Arthur D. Little Inc. estimates, involves technological trade.

Many chemical trade experts now are starting to discount, if not dismiss, the potential impact of new chemical-producing areas. It may be one thing for Middle East countries, for instance, to build huge plants to produce petrochemical products. It is another thing to market those products around the world.

Besides, producing commodity chemicals is only a first step in satisfying a chemical market. These new producing areas will need specialty processing chemicals and advanced downstream products. Consequently, if U.S. companies can improve their technological edge, they will more than compensate for any loss of their feedstock advantage.

How this proves out in practice remains to be seen. Meanwhile, the U.S. industry's representatives in Washington are working more closely than ever with government trade officials to keep them abreast of the industry's concerns. The effort is justified, because, more than ever before, it is government action—or inaction—that dictates what happens in international trade.

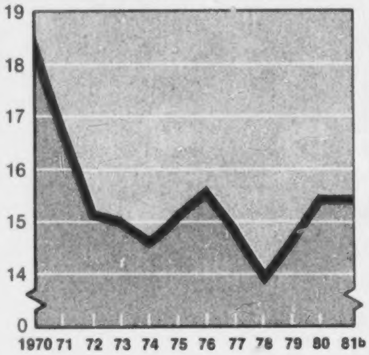
The concerns are many. Enforcing multilateral trade agreements, especially the codes on subsidies and countervailing duties, is one key issue. Another is the apparent shift of emphasis from multilateral to bilateral trade negotiations. Another gigantic effort like the Tokyo round of trade talks, which lasted from 1973 to 1979, is unlikely soon. Yet, bilateral trade talks between the U.S. and other individual countries, although easier to digest, still require a lot of effort and input from industry.

The chemical industry also is concerned about the developing nations, many of which are exempt from some of the trade rules that govern industrialized nations. Their exports often receive preferential, duty-free access to the U.S. and other countries, and rightfully so. However, some developing countries, such as Mexico, Brazil, Taiwan, and South Korea, are more advanced than others and use the same advanced technology that is used in industrialized nations.

The problem is that there are no concrete guidelines that pinpoint when a country has advanced far enough that it no longer warrants preferential treatment.

U.S. share of chemical exports holds steady

U.S. chemical exports, % of world total[a]



a Defined as: U.S. exports as per cent of world chemical exports less U.S. imports. b C&EN estimates. **Sources:** United Nations, Bureau of the Census

Chemical industry leaders also will be watching closely to see what action the Administration may take against foreign investment policies of other nations. Concern about these policies, which may include local production content and export performance requirements, has been building quietly for some time. But it exploded recently as a result of Canada's curbs on foreign investment under its national energy program and its Foreign Investment Review Agency.

But Canada isn't the only offender in the eyes of U.S. trade officials. The list is getting longer and the U.S. soon may move against investment policies that have a distorting effect on trade. Because these policies may violate provisions of the General Agreement on Tariffs & Trade, the U.S. may challenge them in GATT. □

Plastics, fertilizers brake growth in U.S. chemical exports; imports generally are higher

	U.S. chemical exports				U.S. chemical imports			
$ Millions	1981[a]	1980	1979	1978	1981[a]	1980	1979	1978
Organic chemicals	$ 5,872	$ 5,697	$ 5,055	$ 3,369	$3100	$2539	$2159	$1734
Inorganic chemicals	2,205	2,106	2,712	1,207	1584	1323	1106	915
Radioactive materials	996	833	937	717	739	989	953	912
Dyeing, coloring, and tanning materials	191	186	177	145	221	194	185	171
Pigments, paints, and varnishes	339	304	273	241	96	89	76	63
Medicinals and pharmaceuticals	2,205	1,932	1,591	1,404	605	508	441	449
Flavors, perfumes, cosmetics, and toiletries	551	479	399	356	298	301	263	230
Cleaning and polishing materials	382	327	290	250	77	72	73	62
Fertilizers, manufactured	1,760	2,265	1,404	1,091	1190	1104	976	869
Explosives and pyrotechnics	85	87	62	65	67	59	58	43
Plastics and resins	3,858	3,884	3,241	2,088	778	646	626	518
Pesticides and disinfectants	572	553	516	445	288	263	190	159
Miscellaneous	2,184	2,087	1,649	1,240	557	496	379	303
TOTAL	$21,200	$20,740	$17,306	$12,618	$9600	$8583	$7485	$6427

a C&EN estimates. Source: Bureau of the Census

Western Europe

Chemical producers are slimming down to weather economic slump

Excess capacity, weak prices, severe losses in several product lines lead to a restructuring of a hard-beset industry

Dermot A. O'Sullivan, C&EN London

Restructuring for profit is the spirit that pervades chemical companies operating throughout Western Europe. All the majors—among them BP Chemicals, Dow, Du Pont, Essochem, Imperial Chemical Industries (ICI), Monsanto, Montedison, and Shell—are involved to varying degrees.

Changes in corporate structure, shedding of unprofitable business lines, staff trimming, and the like are not unusual, of course. But recognition of the necessity for such moves among the large European chemical firms is more widespread, and more acutely felt, than at any time in the recent past.

"There is pressing need to do something now," declares Walter Schäfer, who oversees developments in chemicals, plastics, and rubber thoughout the 10 countries of the European Economic Community at the Brussels headquarters of the Commission of the European Communities. "Companies must structurally solve the problem of oversupply. It's no good turning to governments or to the EC Commission for help. That would only prolong the period of adaptation and render the cost higher in the long run.

"The problem has existed since 1975," Schäfer continues. "Company executives have overestimated demand, and continued to invest in new capacity. They must now reduce it. So I believe 1982 will be the year of truth."

Reasons for restructuring are obvious. Most plants are running well below capacity. Prices are weak. Profit margins, where they exist, are slim. Indeed, sales in some product areas are being made at an outright loss.

Bulk thermoplastics are among the worst hit this year. Tom O. Hutchison, chairman of ICI's petrochemicals and plastics division, reckons that West European producers are losing about $200 million a month on sales of low- and high-density polyethylene, polypropylene, polyvinyl chloride, and polystyrene. BASF, headquartered in Ludwigshafen, West Germany, figures it has lost some $44 million on its commodity plastics business in this year's first nine months.

It was against this background that Montepolimeri, the plastics production and marketing arm of Italy's Montedison, recently decided to suspend sales of low-density polyethylene in Italy and elsewhere. The company's plants at Brindisi, Ferrara, and Priola have a combined annual production capability of 946 million lb. That's around 8% of Western Europe's total capacity of about 12 billion lb per year for the polymer.

Montepolimeri isn't alone in taking action on low-density polyethylene. BASF has shut permanently its 88 million lb-per-year plant at Antwerp, Belgium. And its joint venture with Deutsche Shell, Rheinische Olefinwerke at Wesseling, West Germany, has cut 352 million lb from its 1.5 billion lb annual capacity. These moves have cut BASF's low-density polyethylene capacity throughout Western Europe about a fifth. Others, like ATO Chimie and CdF Chimie in France and BP Chemicals, ICI, and Shell Chemicals, have taken similar action or are about to do so.

"Behavior in bulk polymers this year has been absolutely disastrous," comments John Harvey-Jones, ICI's chairman-elect, who takes over from Sir Maurice Hodgson next March. "However, I think there will be some improvement next year. There needs to be.

"Basically, it's very difficult to increase prices with vast overcapacities hanging over the market," he says. "But rates of loss like that [which we are seeing] do tend to concentrate the mind. At some stage, the losses eventually get so high that people either are quitting, or [they] decide they can't go on being silly, and start easing off volume and going for price."

Excess capacity extends beyond the thermoplastics. Annual West European demand for ethylene, for instance, is about 24 billion lb, against an installed effective capacity of more than 33 billion lb yearly, according to CEFIC (European Council of Chemical Manufacturers' Federations). "If nothing is done, this overcapacity will remain a thorn in our sides for the rest of the decade," comments Ton Grotens, who heads the petrochemicals and plastics division of DSM in the Netherlands.

Some ethylene units now are being mothballed. Nevertheless, Esso Chemical, Exxon's U.K. subsidiary, is moving ahead with its planned ethane cracker at Mossmorran, near Edinburgh, Scotland, after industry rumors earlier this year that it was reconsidering the project. When it starts up in 1985, it will have an ethylene output capability of 1.1 billion lb annually using ethane derived from North Sea gas. Shell Chemical, which is funding half the cost, will take half the output.

Not surprisingly, other ethylene

producers level criticism at the project. But Essochem and Shell Chemical stress that their situation is somewhat special because Esso and Shell are co-owners of the Brent oil field, some 280 miles out in the North Sea, from which the gas will come.

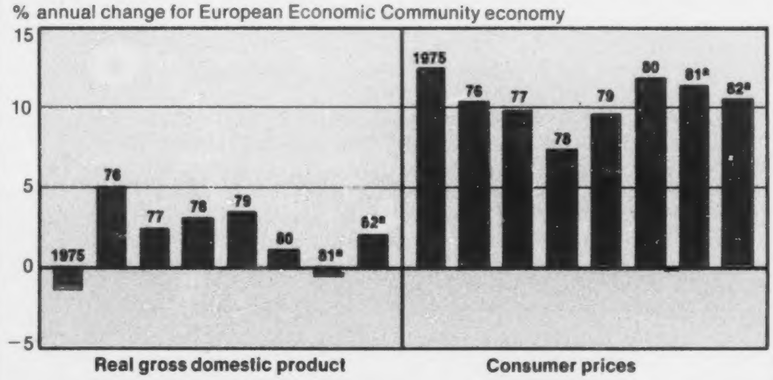
"Although I would not normally comment about a specific U.K. project, the crucial point about Mossmorran is that one must look at it in the context of a much wider envelope than just the chemical side of it," explains Richard Hobbs, head of public affairs for Shell International Chemical in London. "The economics of one part of what is a much more complex envelope is very difficult to show on its own."

Essochem feels strongly that efficiency is the key to remaining competitive in the market. Whereas a great deal of money would be needed to modernize existing older crackers, the Mossmorran unit will be the most modern and sophisticated of its type in Western Europe, the company points out. And it will use locally available, rather than imported, feedstock.

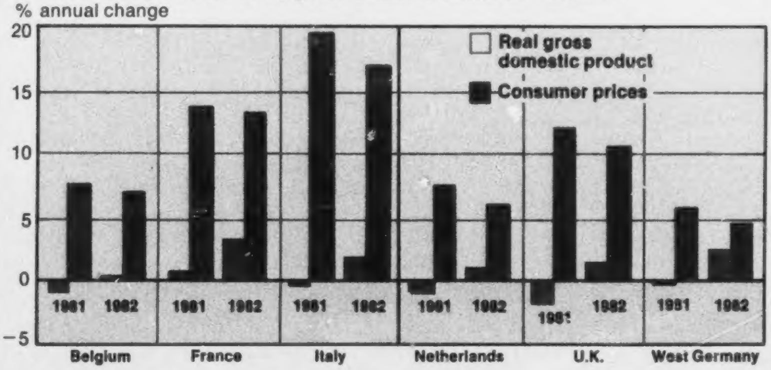
"Essochem plans to continue making improvements to its manufacturing operations," notes David R. Clair, who took over the presidency of the Brussels-based company this year. "We anticipate investing more than $100 million next year on projects that emphasize efficiency. In this way, we will improve profitability without having to rely on growth in demand."

DSM's Grotens observes that about a quarter of Western Europe's ethylene capacity is in plants that were built prior to 1968. "In my view," he says, "the problem of overcapacity can be solved only by an intensive cooperation among cracker operators. Maybe we should look at the possibility of crackers as pooled utilities. This would help eliminate the nonsensical practice of incremental costing, which we have experienced in the last two years, and favor the sensible business practice of integral costing." He proposes "a series of cooperative agreements and a more mature behavior in general, in order to secure an orderly conduct of our petrochemicals business."

Europe's economy remains weak and beset with inflation . . .



. . . with only modest improvement seen for 1982



* Estimated. **Source:** Commission of the European Communities

Hobbs generally shares Grotens' view about the extent of overcapacity. "There is need to get rid of between 15 and 20% of capacity of the problem petrochemicals," he says. "The easy bit is shutting down a second production line, or a small cracker, or something of that sort. One can see one's way to reaching 10%. The next step will entail shutting down an entire plant site. It has got to happen. It's that final 10% that will really make the difference between feast and famine.

"Companies can do arms-length, commercial deals with one another within the ground rules of EEC with the object of making it attractive for one of them to close its plant permanently," he points out. "But it can't be restrictive. It must be a straightforward contract.

"We now are moving into the stage where companies will be fighting to be the survivors. Each will be trying to ensure that it will be the others who will shut down their sites."

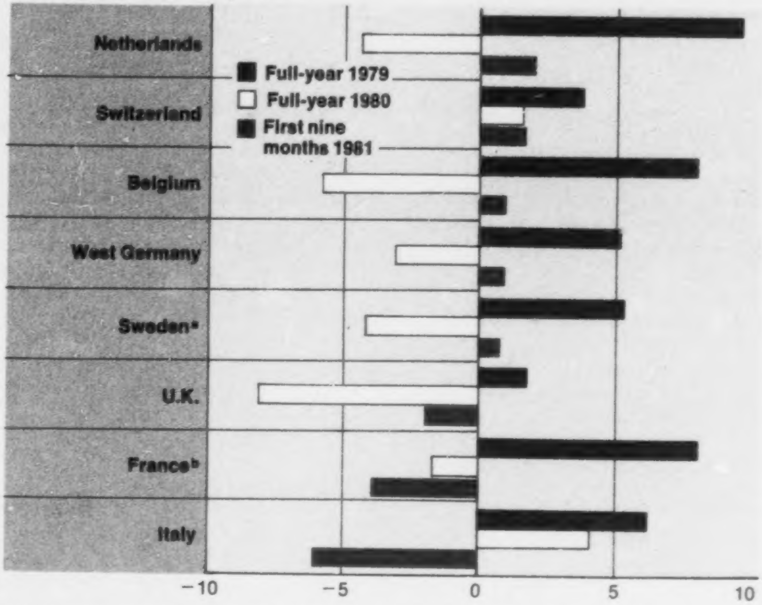
It might have been thinking along this line that prompted Frank P. Popoff, president of Dow Chemical Europe, to make the somewhat startling prediction last May that "the number of [chemical] companies [worldwide] will be drastically reduced by [the year] 2000."

According to Popoff, today's top 13 West European chemical companies will shrink to six in the next 20 years. Which these six might be leads to some interesting speculation.

Petrochemical company executives who now are maneuvering to steer their enterprises toward a more profitable future can be heartened from the positive outcome of steps

Chemical output shows little or no recovery from 1980 slump

% change from previous year



a 1981 figure is for first six months only. b 1981 figure is estimate for full year. **Note:** Data exclude synthetic fibers. **Sources:** National chemical federations for each country

taken by the synthetic fiber and textile companies in Europe, which have undergone major structural changes during the past few years. And the moves appear to be paying off.

Courtaulds of the U.K., severely affected by the fibers and textiles downturn in recent years, showed an after-tax profit of nearly $20 million at the end of its first six months of business this year against a loss of about $5 million during the like period the previous year. ICI, too, might be emerging from its period of losses on fibers. "I'm optimistic that fibers will be right next year," Harvey-Jones believes. "The reason fibers are beginning to come right is because so many plants have gone out of production."

Courtaulds, for example, closed its nylon 6 plants in the U.K. this year. Monsanto stopped production of nylon 66 in Luxembourg and Scotland. And Du Pont is making moves to phase out polyester filament production at Uentrop, West Germany, although it will continue to make polyester staple and fiberfill there, as well as nylon 66 staple and carpet yarn.

Certainly, the job casualty rate in the European fibers business has been severe. All companies have been pushing through rationalization schemes. France's chemicals and fibers giant, Rhône-Poulenc, slated for government takeover under the nationalization program of the socialist government voted into power this year, has had a massive redundancy program under way in its fibers and textiles operations for the past several years. The original plan was to reduce the number of workers employed from 13,000 in 1977 to 4000 next year. But this is now thrown into some doubt under the new government's campaign against unemployment. Meanwhile, ICI has reduced its man-made fibers work force in Western Europe from 25,000 to the present level of 8600 during the past 10 years. "We are producing about the same amount now as we were then," Harvey-Jones remarks, "but the product mix is totally different."

Despite the upturn in European fibers business this year, the picture for the industry is far from rosy. As Mogens T. Andersen, textiles director for Europe and Africa at Monsanto's European headquarters in Brussels, points out, "Man-made fibers production in Western Europe is recovering in line with consumption, but it has not reached 1979 levels, the last good year in volume terms. Consumption in 1980 was 17% below 1979. This year, it is up only 10% from 1980. The prospects are for a continuation of the recovery in 1982, but at a slower pace, perhaps between 3 and 5%. On the other hand, while there has been a modicum of price improvement, costs continue to soar, and profit margins remain squeezed for all fibers."

The word from Du Pont's European base in Geneva, Switzerland, is that sales of industrial fibers are down this year, reflecting the weakness in various industrial sectors. Carpet fibers performed better, particularly bulk continuous filament yarn. The outlook for 1982 remains cloudy, although there are encouraging signs that the European recession is bottoming out.

The general state of the European economy obviously has a profound influence on all sectors of the chemical industry. This year's annual economic report of the Commission of the European Communities, published in October, opens with the somber statement: "It now seems likely that the volume of output will have been, at best, of the same order of magnitude in 1981 as in 1980, compared to the increase of 0.6% forecast a year ago. The recession lasted two quarters longer than expected.

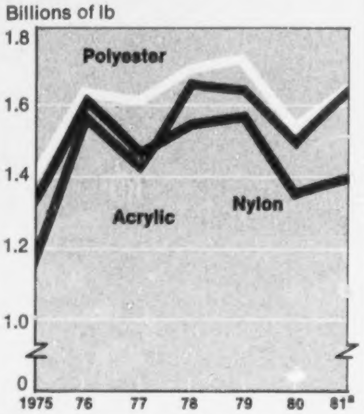
"There was no progress in reducing inflation. Consumer prices are forecast to grow considerably faster in 1981 than originally expected, 11.3% compared to 9.7%. The squeeze on household incomes resulted in a slight fall in the real level of private consumption compared to the 2% gain expected. Investment and stockbuilding performance also was weaker, influenced, no doubt, by the very high interest rates. The lower rate of [economic] activity, and the accelerating labor supply, has raised the level of unemployment [to] 7.8%."

Nor is the outlook for 1982 particularly encouraging. The overall inflation rate, on average, is expected to be 10.5%, led by Greece (22.5%), Italy (16.9%), and Ireland (16.0%). The unemployment rate is likely to move up to 8.5% of the EEC working population. Belgium (12.3%), the U.K. (11.3%), and Ireland (10.9%) will continue to be the worst affected.

EEC economists are looking for a 2% increase in net gross domestic product next year. Should this be realized, it will help the chemical industry, which generally outpaces the GDP rise by a so-called multiplier factor. If, as most chemical analysts expect, the factor is 1.5, chemical output across the board for EEC would advance 3% from this year.

Differences in the cost of electricity from one European country to another is a source of concern for

Fiber production remains below pre-1980 levels



a Estimates. **Source:** CIRFS (International Rayon & Synthetic Fibers Committee)

chemical producers in high-cost locations, such as the Netherlands and the U.K. The anguish is felt most keenly by those engaged in the electrolysis of brine, where electricity accounts for some 80% of chlorine's variable production cost. This feeds through to vinyl chloride and polyvinyl chloride.

"At the present time, the average cost of electricity for this operation in the U.K. is approximately 80% higher than it is for comparable operations in West Germany where ICI also manufactures chlorine," complains ICI's Harvey-Jones. "Even allowing for pound sterling-deutsche mark parity shifts, I'm still paying nearly twice as much for electricity in the U.K.

"We've got the most modern chlorine technology anywhere, brand new plants, and a host of very sophisticated ways of putting added value onto chlorine. But in a case like polyvinyl chloride, we can't compete [from the U.K.]; we lose money. This past year, profitability of our U.K. Mond division [maker of heavy industrial chemicals such as chlorine] has roughly halved, very largely due to high electricity costs."

Europe's petrochemical industry is operating well below capacity

Billions of lb	Total effective capacity	West European market[a]	Average plant capacity utilization %
Ethylene	33.31	24.20	73%
Ethylene oxide and derivatives[b]	1.78	1.19	67
Nylon fiber intermediates	3.87	2.41	62
Polyethylene, high density	4.95	3.30	67
Polyethylene, low density	11.88	9.33	79
Polypropylene	4.09	3.05	75
Polystyrene	5.85	3.70	63
Polyvinyl chloride	10.70	8.65	81

a Includes net exports from West Europe. b Based on ethylene oxide equivalent. **Source:** Imperial Chemical Industries

The most positive development of 1981 for European chemical industry managers is that oil and naphtha prices remained stable. The contract price for naphtha in the first quarter was $358 a metric ton. During this final quarter, it is about 5% less at $340.

But the price in U.S. dollars is only part of the picture. Some very strong West European currency movements against the dollar throughout the year were superimposed on this. "Frankly, it has screwed up the whole picture," bluntly comments Shell International Chemical's Hobbs.

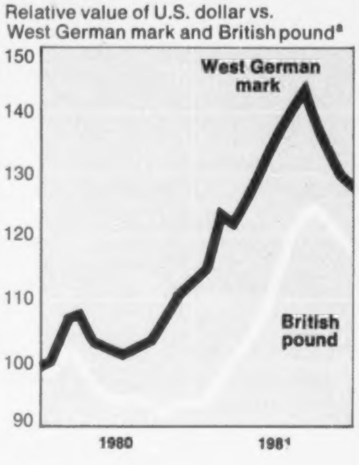
During last year's first half, for instance, the West German deutsche mark remained reasonably stable against the dollar, but since then it lost ground steadily until, by last August, the dollar was worth 45% more than in January 1980. This meant, of course, that West German chemical concerns were paying 45% more for naphtha feedstock in local currency than they were 18 months earlier.

Since August, the dollar has weakened slightly against the deutsche mark, but it still remains relatively strong. The Netherlands has faced the same situation because of the close parity "tie" between the guilder and the deutsche mark.

The pattern of the U.K. pound sterling was somewhat different. It remained strong against the dollar for most of 1980. Last March, it began to weaken and, by September, the dollar had gained in strength almost 33% from last January.

Much the same situation prevailed throughout EEC and the rest of Europe. The EC Commission states in its annual review that "the most conspicuous contributing factor to the differences between the forecast and out-turn [of the EEC economy this year] had been the strong appreciation of the U.S. dollar and the related rise in worldwide interest rates. The 34% increase of the dollar against the ECU that has occurred in the 12 months to September 1981 was very much greater than expected." The ECU, the European currency unit, is the EEC monetary unit based on a weighted "basket" of member countries' national currencies.

U.S. dollar has been strong in Europe this year



a January 1980 = 100

European businessmen, on the other hand, tend to have a split opinion when it comes to evaluating the effect of parity changes on their trade dealings. When their national currencies are weak in relation to the dollar, it hurts when they must buy goods that bear a dollar price tag. But the reverse holds true when it comes to selling their products to dollar-zone countries. And since more than half of world trade is invoiced in dollars, the potential for boosting exports is increased. Throughout Europe, however, chemical products are priced largely in deutsche marks.

No doubt it was this factor that helped Hoechst A.G., the parent company of the worldwide concern headquartered in Frankfurt, West Germany, to advance its export sales 14% between January and September this year compared to the like period in 1980. "In export business," Hoechst management says, "sales volume rose around 7% over the first nine months of 1980. Satisfactory increases were registered by fibers, plastic film, technical information systems, and pharmaceuticals." BASF and Bayer, the other West German chemical giants, likewise posted gains in export markets.

Europe also gained when the strong dollar led to slackening of imports of chemicals from the U.S. Polypropylene imports dropped 57% during this year's first nine months, compared to the like 1980 period. Low-density polyethylene imports were off 53%. There was a noticeable easing, too, of shipments of fibers and other U.S. chemical products to Europe, many of which were subject to dumping complaints a year ago. ☐

Japan

Troubled petrochemical makers seek help in staunching imports

With costs up, exports falling, and domestic demand slow, chemical industry may face structural reforms

Earl V. Anderson, C&EN New York

Japan is in trouble again—or still—because it is doing so well at what it does better than most other countries: exporting. The U.S. and several European countries are putting a lot of muscle on Japan to cut back exports and to open wider its wealthy domestic market to imports.

Japan's petrochemical industry also is in trouble. And a series of meetings have been scheduled in Washington this month and early next year between government and industry representatives of both countries to discuss one of the industry's biggest headaches. That headache is, ironically, the increasingly large barrage of petrochemicals that U.S. companies are exporting to Japan.

There is no doubt that the volume of petrochemicals from the U.S. has been increasing dramatically in Japan. Additional petrochemicals have been coming in from Canada. These imports are certain to increase.

Although this flood of imported petrochemicals is, indeed, a problem for Japan's chemical industry, it

Japanese chemical production is down almost across the board

Thousands of metric tons unless otherwise indicated	1980	Seven months 1981	Seven months 1980	% change
INORGANIC CHEMICALS				
Ammonium chloride	683	340	436	−22%
Ammonium sulfate	1879	1059	1129	−6
Calcium carbide	550	301	342	−12
Calcium superphosphate	591	289	386	−25
Carbon black	575	330	334	−1
Chlorine, liquid	763	443	466	−5
Hydrochloric acid	570	331	328	1
Nitrogen[a]	4586	2995	2650	13
Oxygen[a]	6854	3787	4107	−8
Sodium carbonate	1357	696	828	−16
Sodium hydroxide	3159	1677	1930	−13
Sodium silicate	712	412	409	1
Sulfuric acid	6777	3803	4023	−5
Titanium dioxide	173	101	108	−6
ORGANIC CHEMICALS				
Acetaldehyde	432	186	290	−36
Acetic acid	418	205	258	−21
Acetone	235	123	150	−18
Acrylonitrile	469	281	290	−3
Benzene	2060	1120	1315	−15
Butadiene	574	306	369	−17
Butanol	222	133	142	−6
Caprolactam	443	252	263	−4
Cyclohexane	500	268	297	−10
Dioctylphthalate	241	131	155	−15%
Ethylene	4176	2180	2703	−19
Ethylene dichloride	2060	1018	1313	−22
Ethylene glycol	492	211	308	−31
Ethylene oxide	529	256	333	−23
Methanol	836	447	558	−20
Octanol, synthetic	241	137	152	−10
Phenol	215	119	128	−7
Phthalic anhydride	235	149	152	−2
Propylene	2636	1435	1668	−14
Propylene glycol	163	96	97	−1
Styrene	1114	632	740	−15
Terephthalic acid	601	345	360	−4
Toluene	889	486	564	−14
Toluene diisocyanate	67	33	39	−15
Xylene	1195	688	752	−9
Urea	1770	911	1126	−19
PLASTICS				
Phenolic resins	304	169	185	−9
Polyethylene	1860	1022	1210	−16
Polypropylene	927	552	586	−6
Polystyrene	1129	665	738	−10
Polyvinyl chloride	1429	698	911	−23
SYNTHETIC RUBBER	1094	598	684	−13

a Millions of cubic meters. **Source:** Ministry of International Trade & Industry really is a symptom of a far deeper problem. Japanese refer to it as a "structural" problem. But what it boils down to is that the petrochemical industry, choking on expensive naphtha feedstock (much of it imported), has too many companies with too much capacity cranking out products that are too expensive for a domestic market that is too small.

Exports, traditionally the outlet that is supposed to take up the slack, are becoming increasingly less capable of performing that function. The same competitive edge that is enabling U.S. and Canadian companies to export petrochemicals to Japan is also enabling them to squeeze Japanese petrochemicals out of Japan's all-important export markets in Southeast Asia.

As a result, Japan's chemical exports will decrease this year for the first time since 1976. Its chemical trade surplus will go down for the third successive year. This year's estimated $540 million chemical trade surplus is but a shadow of the $1.8 billion that it was in 1975.

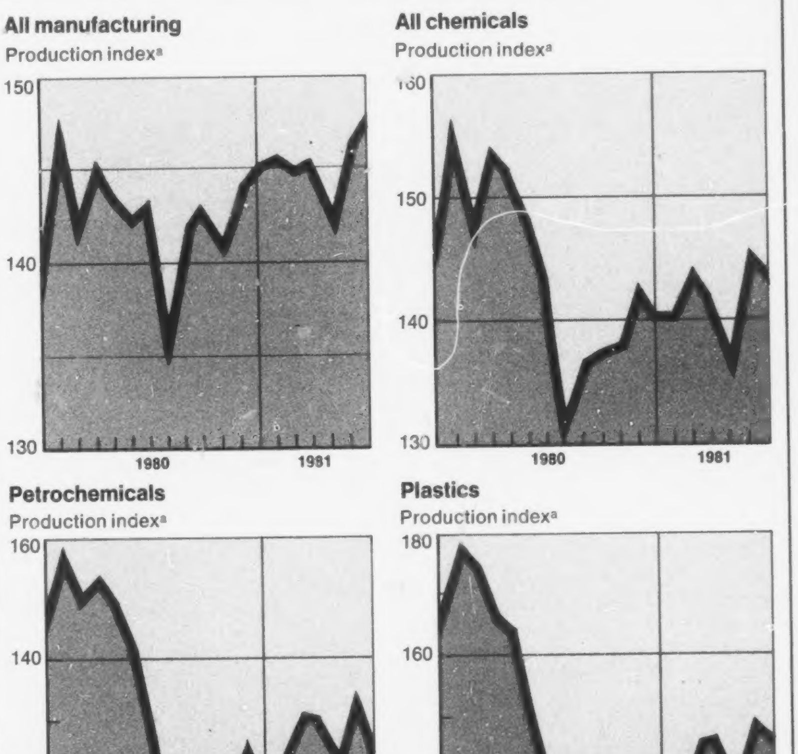
On the Japanese home front, chemical demand has been, to put it mildly, a nightmare. Take a look at chemical production this year. Only two major chemicals (hydrochloric acid and sodium silicate) show any growth through the first seven months. And that's only 1% for each. All the rest are wearing minus signs— some of them very flashy minus signs.

What is happening to ethylene in Japan pretty well typifies the problems plaguing the industry. Recent data indicate that Japan's ethylene output will be about 3.64 million metric tons this year, down 13%, instead of the 19% loss it experienced through the first seven months.

Nevertheless, this will be the first time that ethylene production has fallen below 4 million metric tons in Japan since 1977 and output will be the lowest since 1975. Producers, with a combined capacity of 6.2 million metric tons, are operating at a paltry 58% of capacity.

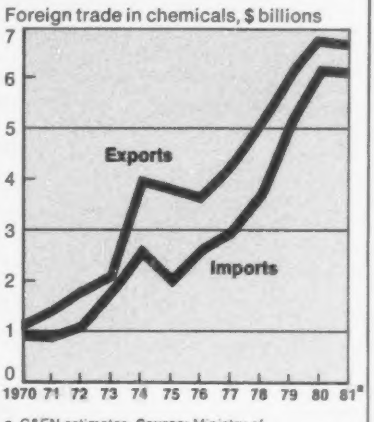
How will Japan handle its dichotomous problems? Again ironically, solving its overall trade problems with the U.S. and Europe may prove to be easier than solving its petrochemical dilemma. Responding to pressure

Chemical output remains under year-ago levels



a Seasonally adjusted, 1975 = 100. **Source:** Ministry of International Trade & Industry

Japan's chemical trade balance is narrowing



a C&EN estimates. **Source:** Ministry of International Trade & Industry

from its trading partners, Japan already is taking steps to curb exports and to increase imports.

Meanwhile, a steadily strengthening yen may act as a natural brake on Japanese exports. The yen, partly in response to falling interest rates in the U.S., has been rebounding lately. In late November, the exchange rate was 226 yen to the dollar. It has been gaining ground since then and experts think that the rate will hit between 200 and 210 yen to the dollar by the end of the year.

A stronger yen, of course, makes Japanese exports more expensive. Demand for them in overseas markets should drop.

That's fine for Japan's international political-economic problems. But curbing chemical exports will hurt, not help, its ailing chemical industry.

It's risky to predict what will come out of the proposed petrochemical trade talks with the U.S. But it's not too risky to speculate that, if the results don't satisfy Japan's Ministry of International Trade & Industry, the agency may consider taking some tough, unilateral steps. These could include quotas, higher tariffs, or even an import surcharge such as the European Economic Community imposed on U.S. chemical exports during the past few years.

Japan attributes the U.S. petrochemical export advantage to lower feedstock costs, particularly those based on regulated natural gas. If natural gas prices are deregulated, U.S. companies will lose some of that advantage vis-a-vis Japan. But not a whole lot.

The Fuji Bank estimates that the difference in Japanese and U.S. ethylene prices will shrink from 40% in 1980 to about 20% in 1990. That's a long way off.

Obviously, Japan has to do something about its petrochemical import problem. That's important. But many chemical experts there think that restructuring the industry is crucial. Leaders in both government and industry are working on it. But it won't be easy.

Some steps already have been taken, however. Imports, along with excess capacity and weak markets, prompted Japan's polyvinyl chloride industry to form an antirecession cartel six months ago. That cartel was extended last month because demand had not increased and inventory adjustment wasn't adequate. In the coming months, cartel members must hold production to 109% of the September-October monthly average.

Now, a proposal has been made to mold the 17 polyvinyl chloride producers into four joint sales companies. This, according to Hiroshi Takahashi, president of the Japanese PVC Association, should help to reduce competition.

What is happening in PVC may be a precursor to what eventually will happen to the entire petrochemical industry. In an interim report to the government, the Industrial Structure Council suggests that the industry reduce the number of manufacturers through mergers, thus eliminating excessive competition.

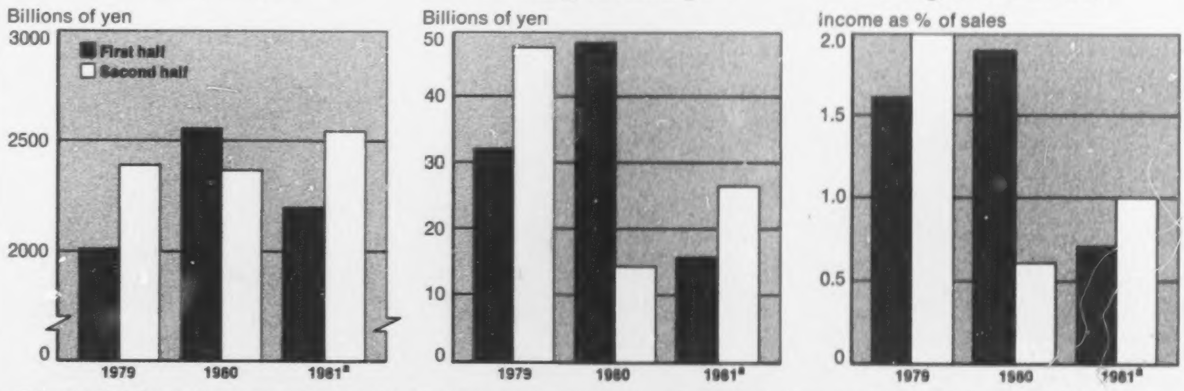
It also urges the government to take steps to ease the industry's feedstock problems. Among them: Continue the tax exemption on imported naphtha, consider exempting domestically produced naphtha from taxes, and improve the nation's naphtha importing procedures, perhaps through a joint importing company.

With or without structural reform, Japanese chemical companies are hoping that the domestic market picks up soon so that they can get some relief from their present troubles.

Responding to a recent questionnaire sent out by the Japan Chemical Industry Association, most chemical companies rated their third quarter business from "bad" to "very bad."

The consensus is, however, that fourth-quarter results will show some improvement. But a significant gain for the chemical industry may have to wait until next year. ☐

Petrochemical firms, sweating out a poor year, look for second-half relief



a Estimated. **Note:** Data for fiscal years ending March 31. Based on results of 10 leading Japanese petrochemical companies: Mitsubishi Chemical Industries, Sumitomo Chemical, Asahi Chemical Industry, Toray Industries, Mitsui Toatsu Chemicals, Teijin, Showa Denko, Mitsubishi Petrochemical, Dainippon Ink & Chemicals, and Sekisui Chemical. **Source:** Toyo Kelzai Shinposha

Canada

Cost/price squeeze burdens chemical firms in Canada

Flourishing recently, exports will have to become even more important as big petrochemical expansions come on stream

Earl V. Anderson, C&EN New York

Along with all Canadians, Canadian chemical producers have watched the bitter struggle between the federal government and the provinces over repatriating, or "bringing home," Canada's constitution from the British Parliament.

Because petrochemical feedstocks are so important to the industry's future, they have watched with more interest than most the equally bitter fight between Ottawa and Alberta over energy pricing and revenue sharing. The complicated agreement that ended the dispute raises the prices of domestically produced oil and natural gas, although it keeps those prices below world market levels. It came in September only after Alberta unilaterally cut back its oil production to protest federal policies. Although it was better than no agreement at all for the chemical industry, not all chemical companies are satisfied with it.

On the economic front, the chemical industry's hopes early in 1981 for recovery faded into later disappointment. The winds of a recession in Canada, which everyone knew was coming as a result of tight monetary policies and high interest rates, started blowing in earnest during the third quarter. Now it appears that the recession is going to be deeper and longer than anyone expected.

The new federal budget, recently introduced by Finance Minister Allan MacEachen, was a disappointment to those who were hoping for economic stimulus. Admittedly designed to reduce interest rates and inflation, the budget won't do much to spur a lagging economy, according to many Canadian economists who see it as the wrong medicine for Canada's present economic ills. As a result, they are adjusting their forecasts of economic growth in 1982 downward. Earlier projections, which had 1982 real growth in gross national product ranging from 2.5 to 3.5%, now have been revised to about 1.5% or lower—perhaps much lower.

If these economists are right, it will be some time before Canadian chemical companies return to bottom-line respectability. It now appears all but certain that for the chemical industry, business during most of next year will resemble this year's second half.

It was in the second half of 1981 that the industry's profit picture started falling apart. Production volume was not the problem. With the exception of a few heavy inorganic chemicals, such as sulfuric acid, phosphoric acid, and ammonium phosphate, output of most important chemicals increased in 1981, if only marginally.

Some products scored significant increases. Ethylene, for instance, will be up about 12% this year and plastics production remains strong. Output of high-density polyethylene, for example, probably will rise 14%.

What, then, is the problem? For most Canadian chemical companies, it is a classic cost-price squeeze. Although chemical selling prices are rising in Canada, they are not rising so rapidly as feedstock costs, particularly for petrochemicals.

Tough competition in a small domestic market among Canadian companies and against imports makes it difficult for producers to raise prices enough to cover increased feedstock costs. The same is true in export markets, where competition

Production of chemicals will grow only modestly in 1981

Thousands of metric tons	1977	1978	1979	1980	1981[a]
Ammonia	2162	2398	2405	2555	2650
Ammonium nitrate	925	871	914	873	900
Ammonium phosphate	1147	1178	1336	1466	1395
Benzene	383	555	492	604	625
Chlorine	888	941	1031	1303	1295
Ethylene	567	826	1014	1184	1330
Hydrochloric acid, 100%	136	155	154	177	185
Phosphoric acid, 100% P_2O_5	556	554	748	808	750
Polyethylene, high density } Polyethylene, low density	345	478	200	202	230
			428	439	475
Polystyrene	91	99	124	110	125
Polyvinyl chloride	100	125	145	190	230
Sodium chlorate	162	199	224	245	300
Sodium hydroxide	1014	1036	1138	1459	1460
Sulfuric acid	3140	3261	3666	4295	4060
Urea	805	1217	1212	1274	1425

a C&EN estimates. Source: Statistics Canada

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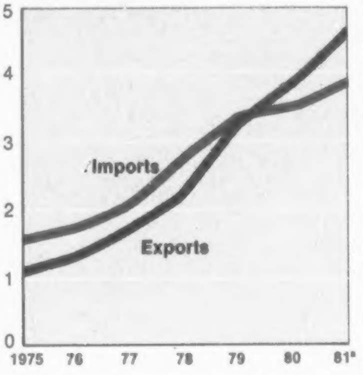
Chemical trade moves more strongly into black

Chemical foreign trade, $ billions (Canadian)



a C&EN estimates. Source: Statistics Canada

throughout the world is intensifying.

The result is becoming apparent in chemical company financial statements. Using the combined results of four top Canadian chemical companies (C-I-L Inc., Celanese Canada, Du Pont Canada, and Union Carbide Canada) as a guide, it becomes painfully clear what the industry may be up against for most of next year.

In the happier days of 1981's second quarter, the combined sales and earnings of these four companies increased 15% above the first quarter. Profit margins also increased slightly. In the third quarter, however, sales were off 17% and earnings dropped a hefty 50%.

Things might have been worse had it not been for exports. Despite increased competition, Canada's chemical exports are flourishing. As a result, the long-standing deficit in the country's balance of chemical trade swung into an $88 million (Canadian dollars) surplus in 1979. This year, a 17.5% increase in chemical exports (to $4.7 billion) will raise the chemical trade surplus to $900 million.

How chemical exports will fare next year remains to be seen. Fertilizer and organic chemicals are the two leading Canadian chemical exports, accounting for more than half of the total. One problem is that more than half of Canada's total exports are shipped to the U.S., which faces an economic slump of its own. This could put a crimp in the growth of Canada's chemical exports, and the industry's concerted effort to crack Far East chemical markets may not be able to take up the slack.

One thing is certain. The world-scale petrochemical plants being built in gas-rich Alberta, and to a lesser extent in British Columbia, are geared to the export market. Companies building them will push export sales as hard as possible.

The Canadian petrochemical buildup is awesome. According to a recent count, 10 major petrochemical projects have been approved and are being built in western Canada, at a combined capital cost of $2.4 billion. All but one (Ocelot's methanol unit in British Columbia) are going up in Alberta.

Alberta's second major ethylene plant is expected to be on stream by 1984 and a third unit has just been approved. Plans already are under way for a fourth ethylene plant, which probably will come on stream around 1987.

There is little doubt that these plants will be needed. In addition to the 10 projects approved and under construction, an additional dozen projects are being planned and are in the approval mill. Most of these units will produce ethylene derivatives; all but one will be built in Alberta. Together, they will add another $5.2 billion to Canada's petrochemical investment.

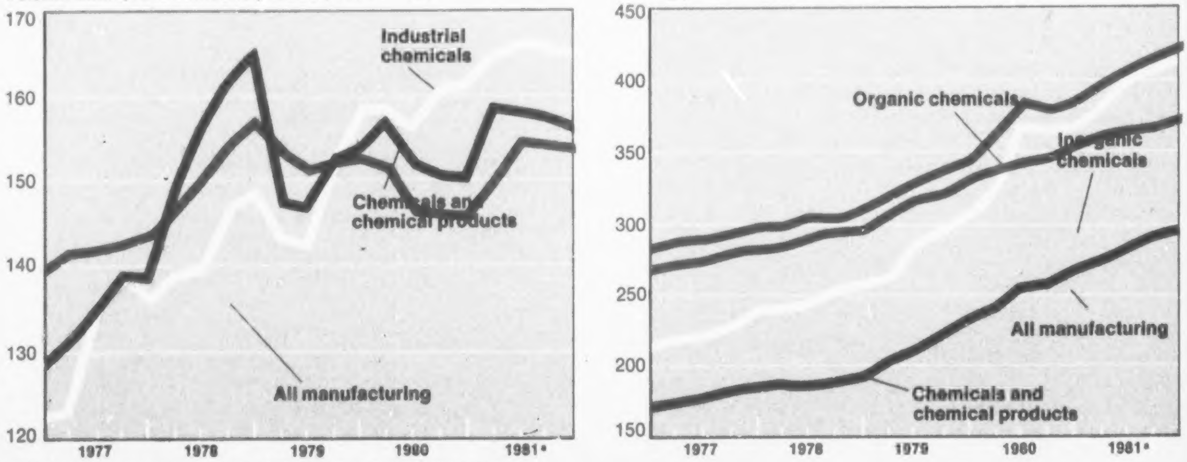
Even if some of these projects are scrapped, it's obvious that Canada will become a petrochemical force to reckon with. Installed ethylene capacity alone is expected to hit 2.85 million metric tons a year by 1987.

The outlook isn't that rosy for producers in eastern Canada. Not only will they have to contend with new competition from the West, but they will have to rely on more expensive, oil-based feedstock. Union Carbide's recent decision to defer expansion of its polyethylene plant at Sarnia, Ont., may be a harbinger of the problems eastern producers will be facing.

Originally, Canada's National Energy Program stipulated that oil prices would not rise above 85% of world prices. The September agreement between Ottawa and Alberta changed that. The blended price (of conventional old oil and new oil) at the refinery gate now can exceed 85% of world prices. And changes in natural gas pricing also tend to increase the advantage for natural gas-based petrochemical producers. □

Chemical output peaked early this year ... **... but prices are rising sharply**

Volume index, real domestic product, 1971 = 100 Selling price index, 1971 = 100



a Third- and fourth-quarter 1981 are C&EN estimates. Source: Statistics Canada

U.S.S.R./
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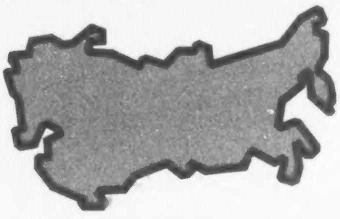


Output is falling short of targets in Eastern Europe

Despite slowing growth chemicals continue to rate high priority in economic plans of Soviet Union and its allies

Richard J. Seltzer, C&EN Washington

This month, the Soviet Union and its six East European allies in the Council for Mutual Economic Assistance (CMEA)—Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, and Romania—complete the first year of their new five-year plans (1981–85). The chemical industry receives high priority in these development plans, and it is continuing to make considerable progress. However, as with many economic and industrial sectors, chemical operations in CMEA countries generally are falling short of national targets.

The problems are many: shortages of raw materials, labor, and energy; construction and transportation bottlenecks; low productivity; poor product quality; wasteful use of resources; inefficient industrial management; disincentives to innovate and adopt new processes; and outmoded technology and equipment.

Information is sparse about economic results for 1981 and goals for 1982 and 1985 (and western analysts often express doubts about the reliability of official statistics). However, it appears that this year the Soviet and East European economies generally are continuing the slower growth of the past two years. Capital investment and imports of technology and plants are being cut back. And the outlook is for continued slow growth at least through 1985, as government leaders set less ambitious goals in their new five-year plans.

Thus, industrial production for the six East European nations (excluding the U.S.S.R.) rose just 2.5% in 1980, according to the United Nations Economic Commission for Europe (ECE), based on official national figures. This was less than half the target of 5.2% and represents a continuation of the slowdown in the region's industrial growth rates since 1976 (7.4% in 1976, 7.0% in 1977, 5.7% in 1978, and 4.4% in 1979). Furthermore, Central Intelligence Agency estimates of growth are even lower—2.7% in 1979 and 1.3% in 1980, for instance. (The CIA postulates upward bias in official figures due to double counting and disguised inflation.)

Industrial growth slowed in every East European country in 1980, according to ECE, particularly in Hungary (where output dropped 2% in 1980, compared to expansions of 3.0% in 1979, 4.9% in 1978, and 6.6% in 1977) and Poland (down 1.3% in 1980, compared to increases of 2.7% in 1979, 4.9% in 1978, 6.9% in 1977, and 9.3% in 1976). The contraction sharpened this year for Poland, with industrial production down 13% from 1980 for the first three quarters.

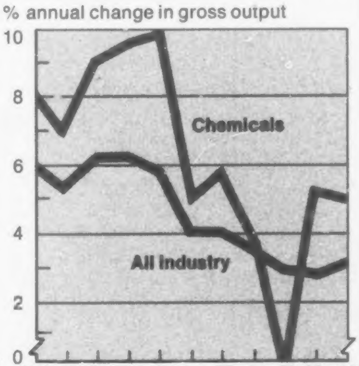
Beleaguered Poland's precipitous drop pulls down the region's overall results in two ways. First, it mathematically lowers the region's average growth rate. Thus, in the first half of 1981, according to ECE, industrial output of the six East European nations as a whole plummeted to a negative growth rate for the first time, declining 1% (the goal was a 4% rise). Five of the six nations increased their industrial output compared to last year (up between 2 and 6%), albeit at slower growth rates than in 1980. But Poland's decline more than outweighed the others' rise. Furthermore, Poland is an important supplier to its neighbors' industries, and failure in its deliveries directly affects their industrial output.

For the Soviet Union, U.S. government estimates show a slight slowing in growth of industrial production last year, as well as in 1979 (2.9% in 1980, 3.0% in 1979, and 3.5% in 1978). Industrial output thus failed to meet its target for 1980 of a 4.5% increase. This year, Soviet industrial production is growing at a slightly higher rate—3.3% through October. However, this still falls well short of the year's goal (4.1%).

Chemical and rubber industry production slowed last year, as well, in several East European countries. Chemical and rubber output in Hungary, for example, declined 0.1% in 1980, compared to increases of 6.1% in 1979 and 10.7% in 1978. However, production recovered somewhat in several countries from the general slump in 1979. Thus, Romania's chemical and rubber output rose 6.7% in 1980, compared to only 1.4% in 1979.

Chemical industry in the U.S.S.R. also rebounded, with 5.2% growth in production in 1980, compared to 0.2% in 1979, according to U.S. government calculations. However, this was still far short of the 1980 plan target of 9% growth, and well below the annual growth rates of 7 to 10% for chemical production racked up during the

Soviet chemical growth slower than in early 1970's



a Preliminary figures. b For 10 months. **Note:** All figures except for 1981 are based on Central Intelligence Agency estimates, giving lower results than official Soviet statistics because of postulated upward bias in Soviet figures. **Sources:** Central Intelligence Agency, U.S. Department of Commerce

U.S.S.R.'s ninth five-year plan (1971–75).

This year, Soviet chemical production through October is up 5.0% from the same period last year—just even with the year's target rate (although a bit below last year's 5.2% growth). However, production of some key chemicals is falling well short of targets.

For example, mineral fertilizer production, on a gross weight basis, rose 10% in 1980 (to 104 million metric tons), and 5% through August this year (compared to the same period in 1980), both seemingly respectable growth rates. However, the goal for 1980 was a 22% rise, to 115.3 million metric tons (and this target itself was scaled back drastically from the original five-year plan target of 143 million metric tons by 1980). And the 1981 target is a rise of 9.4%, to 113.8 million metric tons, compared to the 5% achieved through August of this year.

Making things worse for an already problem-plagued Soviet agriculture, pesticide production also continues to fall far short of targets. In 1980, output declined for the second straight year, down 1.1% to 470,000 metric tons. (The goal was 8% growth, to 512,000 metric tons, and this was a severe cutback from the original five-year plan goal of 615,000 metric tons.) This year, output is up 6% through October. However, 6% growth for the year would yield only 498,000 metric tons, still well short even of the goal for 1980.

Similarly, output through October this year of synthetic resins and plastics was 3.4 million metric tons, up a creditable 11% but still far below the rate of 18% needed to meet the year's goal of 4.3 million metric tons. And production of chemical fibers and yarns was up just 4% through October (to 1.013 million metric tons), making unlikely achievement of the year's goal of a 10% rise to about 1.3 million metric tons.

Thus, already before its first year is over, doubts are cast upon fulfillment of the supposedly moderate and more realistic goals of the 11th Soviet five-year plan. A few weeks ago, Nikolai K. Baibakov, chairman of the State Planning Committee (Gosplan), told the Supreme Soviet (the nominal Soviet parliament) that in 1981–85 industrial production will grow 26%, an average of nearly 5% a year. For 1982, the goal is 4.7% growth. Top priorities include food production, fuels (especially natural gas, to grow almost 50% by 1985), machine building and metal working, and the petrochemical and chemical industry.

Output of the chemical and petrochemical industry is to grow about 30 to 33% by 1985, an average of about 5.5 to 6% a year. Production of mineral fertilizers is to reach 150 million to 155 million metric tons (gross weight basis) by 1985—up 44 to 49% from production last year for an average annual growth of 7.5 to 8.3%. (The goal this year is 9.4%, but growth totaled only 5% through October.) And chemical fibers and yarns are to reach 1.6 million metric tons by 1985, up 33% from production in 1980, about 6% a year.

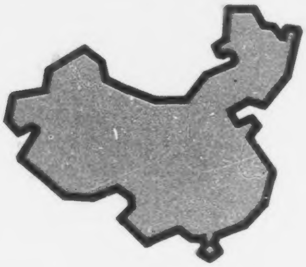
Meanwhile, Romania's five-year plan has set a target of 10.2% growth per year for its chemical industry. Czech output of chemicals is planned to increase a whopping 15% annually through 1985, with emphasis on value-added products, such as reinforced plastics, and ethylene, propylene, and other petrochemicals. Czech fertilizer production is to rise 13% a year. Bulgaria's investment in chemical industry will concentrate on production of polypropylene and ethylene glycol, with construction of a polyurethane complex also scheduled.

In the past, notes an ECE report, the Soviet and East European economies went through a period of extensive growth based on virtually unlimited labor and material inputs. This period is over, and all of these countries are reacting to it by bringing qualitative growth to the fore, including such factors as labor productivity, technical progress, and management efficiency. Thus, for example, Soviet leaders hope to attain almost 90% of their increased industrial output through 1985 by a 23% increase in labor productivity. Imports of machinery and know-how from the West obviously will be critical in such efforts. Indeed, Baibakov points out, the Soviet five-year plan calls for introduction of more than 2700 automated process control systems and 7300 computer complexes based on microprocessors and minicomputers. □

Soviet output of chemicals fails to match plans

Millions of metric tons unless otherwise noted	1981		1980		1979		1978
	Plan	10-month result	Plan	Result	Plan	Result	result
Mineral fertilizers[a]	na	21.9	na	24.8	na	22.1	23.7
% increase[b]	na	5%[c]	na	11.9%	na	−6.4%	0.7%
Sulfuric acid (100%)	na	19.9	na	23.0	na	22.4	22.4
% increase[b]	na	4%[c]	na	2.8%	na	−0.2%	6.2%
Sodium carbonate (100%)	na	na	na	4.8	na	4.8	4.9
% increase[b]	na	na	na	0%	na	−1.6%	−0.4%
Synthetic resins and plastics[d]	4.3	3.4	na	3.6	3.8+[e]	3.5	3.5
% increase[b]	18.3%	11%[c]	na	4.6%	9.3%[e]	−1.1%	6.3%
Sodium hydroxide (100%)	na	2.3	na	2.8	na	2.7	2.8
% increase[b]	na	0.2%[c]	na	2.8%	na	−3.0%	4.0%
Chemical fibers and yarns	1.3[e]	1.0	na	1.2	1.2[e]	1.1	1.1
% increase[b]	10.5%	4%[c]	na	6.9%	4.6%	−2.7%	4.0%
Pesticides and herbicides[f]	na	417	512	470	na	475	491
% increase	na	6%[c]	7.8%	−1.1%	na	−3.5%	1.0%
Automotive tires[g]	na	50.3	na	60.1	na	60.0	59.0
% increase[b]	na	0.1%[c]	na	0.2%	na	1.7%	2.8%

[a] On basis of nutrient content (N, P_2O_5, or K_2O, respectively); including some products used for technical purposes. [b] Increase or decrease from result in previous year. [c] Increase or decrease from 10-month result in previous year. [d] Including resins for man-made fibers. [e] Approximate. [f] In thousands of metric tons. [g] In millions of units. na = not available. Sources: U.S. Department of Commerce, Central Intelligence Agency



China's economic readjustment is aimed at more selective growth

Output is down this year in chemicals and other heavy industries and investment in chemical plants has been slashed

Richard J. Seltzer, C&EN Washington

Three years ago, the People's Republic of China launched its "economic readjustment" program. Calling for sweeping restructuring of the economy and industry, introduction of aspects of a market economy, reallocation of resources, and slower, more selective growth, this policy was adopted after China found its underdeveloped industrial, agricultural, and educational systems incapable of implementing its ambitious development plans.

However, China now is confronting additional economic problems, some of them compounded by its economic reforms—including inflation, high unemployment, serious energy shortages, inadequate supplies of building and raw materials, large budget deficits, and excessive, inefficient investment spending. Thus, it is not surprising that Premier Zhao Ziyang announced earlier this month to the National People's Congress (NPC), China's nominal legislature, that the original three-year readjustment period, 1979–81, will be extended for at least five more years. It thus will cover the entire sixth five-year plan (1981–85) and lay the basis for more rapid growth later.

1981 has been a mixed year for China's industry, with light industry doing relatively well but heavy industry declining precipitously. For the first half of the year, overall industrial production rose just 0.8% compared to the same period last year. It is doubtful that even the relatively modest goal of 6% growth for the year will be met.

The readjustment policy calls for more priority for light and textile industries (producing for export and for consumer needs) and for less priority for heavy industry. Production in light industry rose 11.6% through June, compared to the same period in 1980. It is expected to be up [illegible] for the year, surpassing the target of 8%. Textile industry output increased 15% through June. And production of goods for Chinese consumers soared—television sets up 100%, radios up 64%, cameras up 52%, and bicycles, watches, and sewing machines up about 25% each.

The main reason for the low growth of production overall, therefore, is an absolute decline by heavy industry. For the first half of this year, heavy industry's output dropped 8%. Heavy industry provided just under half of China's total industrial output during the first half of 1981, compared to 53% for all 1980 and 57% in 1979.

Production is lower this year than last year in numerous branches of heavy industry. For example, comparing the first eight months of 1981 with the same period of 1980, petroleum production is down 5.2%, coal 3.6%, natural gas 10.3%, steel 6.3%, power generating equipment 74%, machine tools 20%, motor vehicles 20.4%, tractors 43.1%, railroad freight cars 28.5%, and locomotives 21.7%.

Similar results are found in the chemical area. For instance, chemical fertilizer output dropped 3.9%, sodium hydroxide 4.9%, insecticides 9.2%, pharmaceuticals 18.8%, and rubber tires a whopping 44.5%. Two brighter spots are synthetic detergents (up 11%) and man-made fibers (up 16.5%).

Two factors are causing an economic decline in 1981—and probably also in the next few years—from the high growth rates of 1978–80, according to economist Nicholas Lardy of Yale University. First, a significant part of the 1978–80 growth in industrial output simply represented recovery from the troubled Cultural Revolution period.

Fertilizer, resins spur China's chemical trade deficit with U.S.

$ Millions[a]	Nine months 1981	1980	1979	1978	% change 1979–80
Total exports	$14,770	$19,588	$13,718	$10,086	43%
Total imports	14,180	19,348	14,283	10,321	35
World trade balance	**590**	**240**	**−565**	**−235**	—
Exports to U.S.	1,410	1,054	591	324	78
Imports from U.S.	2,677	3,754	1,724	821	118
Trade balance with U.S.	**−1,267**	**−2,700**	**−1,133**	**−497**	—
Chemical exports to U.S.	95	101	49	22	106
Inorganic chemicals	na	32	19	4	68
Essential oils	na	14	6	7	133
Chemical imports from U.S.	275	390	127	61	207
Inorganic chemicals	na	20	14	2	43
Synthetic resins	na	118	31	2	281
Fertilizer	na	153	45	39	240
Pesticides	na	32	19	10	68
Chemical trade balance with U.S.	**−180**	**−289**	**−78**	**−39**	—

a F.o.b. basis; figures generally are based on data from China's trading partners. na = not available. **Sources:** Central Intelligence Agency, U.S. Department of Commerce

In addition, Lardy points out, the Chinese government has not dealt adequately with structural problems, such as inefficient use of resources and declining energy production. Output of coal, petroleum, and natural gas has declined since 1979. China has not invested sufficiently to modernize coal production, despite huge coal reserves, and has not brought new oil fields into production rapidly enough to offset dropping production in existing fields.

China also has moved very slowly to bring offshore oil into production. (Public bidding is supposed to start early next year for the 48 firms from 13 countries that explored for oil off China.) Thus, China's oil production may not increase significantly until the late 1980's. This raises doubts both about availability of fuel and feedstock for its petrochemical industry and its ability to export oil to enable it to acquire foreign plants and technology. Moreover, China has done little until now to conserve energy or use it more efficiently.

It now appears that the Chinese are "readjusting the readjustment policy," as one China-watcher puts it. Concerned at the rapid decline in heavy industry's output, they realize that a heavy industry base is needed to support expansion of light industry and agriculture. Indeed Zhao told the NPC that heavy industry's output has begun to rise, and will be down only 5% from 1980 for all 1981. Next year, he expects heavy industry to show absolute growth.

Output of many chemicals down this year

Thousands of metric tons, unless otherwise noted	Eight months 1981	Eight months 1980	% change 1980–81
Chemical fertilizer[a]	8243	8578	−3.9%
Nitrogen (N)	6499	6834	−4.9
Phosphate (P_2O_5)	1736	1653	5.0
Potassium (K_2O)	8	8	−2.5
Sulfuric acid (100%)	5089	5130	−0.8
Sodium hydroxide	1253	1318	−4.9
Sodium carbonate	1093	1083	0.9
Calcium carbide	955	985	−3.0
Plastics	602	612	−1.6
Insecticides	354	390	−9.2
Ethylene	336	330	1.8
Synthetic detergents	313	282	11.0
Man-made fibers	240	206	16.5
Pharmaceuticals	23	28	−18.8
Rubber tires (thousands of units)	4880	8793	−44.5

[a] Nutrient content basis. Source: U.S. Department of Commerce

Furthermore, to deal with its economic problems, China has reduced government spending and its budget deficit and has cut back capital construction. First priority in investment goes to light and textile industry, followed by the weak infrastructure sectors of energy, building materials, transport, and communications.

In fact, in late 1980 and early 1981, the Chinese suspended or canceled more than $2 billion worth of industrial plant purchases from abroad, more than 20% of their total plant orders since 1978. These included several petrochemical plants ($1.2 billion), steel-rolling mills ($700 million), and a copper smelter ($100 million). Two factors weighed heavily in the decision: lack of domestic funds for costs related to construction and infrastructure preparation and the likelihood of inadequate fuel and feedstock supplies for the plants.

About 60% of the contracts were with Japanese firms. These firms have since arranged a $1.3 billion credit package enabling work to continue on two projects—the Daqing petrochemical project and the Baoshan steel complex.

In general, China has lowered orders sharply for complete industrial plants, focusing instead on technology and equipment to upgrade existing facilities. And it is very interested in acquiring western equipment and technology through countertrade deals.

U.S.-China trade overall is expected to total about $5.5 billion to $5.8 billion this year, up from $4.8 billion in 1980. Although that is a hefty 15 to 20% rise, it still is a leveling off from the geometric rates of increase of previous years. China is already the U.S.'s largest communist trading partner (indeed, U.S.-China trade through August was 92% of total U.S. trade with the U.S.S.R. and its six East European allies). Trade with the U.S. constituted 14% of China's foreign trade through September.

U.S. exports to China (more than half of which are agricultural products) increased only slowly this year (up 4% through September), whereas U.S. imports soared 89%. (Much of the import increase was $180 million worth of peanuts because of the U.S. peanut shortage.)

U.S. chemical exports, totaling $275 million, contributed $180 million to the U.S. trade surplus of $1.3 billion through September. These figures, furthermore, do not include $401 million worth of man-made fibers exported by the U.S. through September.

In line with China's development priorities, agricultural chemicals, synthetic fibers for textile use, and plastic resins for consumer goods head the list of chemical-related U.S. exports. Indeed, noncontinuous polyester fibers ($208 million) and polyester continuous textured yarn ($111 million) rank third and fourth among all U.S. exports to China through September. Diammonium phosphate fertilizer ($56 million) ranks seventh and polyester resins ($28.6 million) is 10th. Also high on the list are polyester woven fabrics ($23.5 million), noncontinuous acrylic fiber ($23.4 million), polypropylene resins ($20.8 million), concentrated superphosphate ($14.7 million), urea ($13.3 million), dimethyl terephthalate ($11.7 million), insecticides ($11 million), polystyrene homopolymer resins ($10.7 million), and acrylonitrile-butadiene-styrene resins ($10.2 million).

U.S. chemical imports from China ($95.2 million through September) are dominated, as in previous years, by inorganic chemicals and natural products. Fireworks ($17.9 million) ranks ninth among all U.S. imports, and ammonium molybdate ($13.6 million) ranks 12th. Other top imports are ammonium tungstate ($4.8 million), antimony oxide ($3.9 million), menthol ($3.2 million), cassia oil ($3.2 million), synthetic vitamin B_1 ($3.2 million), gum rosin ($3.1 million), synthetic vitamin C ($1.9 million), and caffeine ($1.8 million). □

Middle East

Exports are the vital element in major chemical buildup

Middle East will become a bigger factor in world markets as new plants come on stream in Saudi Arabia and Israel

Dermot A. O'Sullivan, C&EN London
Richard J. Seltzer, C&EN Washington

When petrochemical executives talk of the Middle East, their thinking tends to focus predominantly on Saudi Arabia, for it is there that by far the largest concentration of plants will be sited in the near term.

During this past year, the government-owned Saudi Basic Industries Corp. (SABIC) signed agreements to build petrochemical plants with Celanese and Texas Eastern, Dow Chemical, and a Japanese consortium headed by Mitsubishi. With the signing, the final parts of a complex scheme that will lead to production of an extensive range of products took concrete shape. The present schedule calls for all units to be completed and running by 1986.

This year's three SABIC contracts entail plants that will go in at Al Jubail on the Persian Gulf. National Methanol Co., in which Celanese and Texas Eastern each have a 25% interest, will be designed to produce 1.4 billion lb annually of methanol. It will be sited near a 1.3 billion lb-a-year unit that Saudi Methanol Co., in which SABIC is partnered with a Japanese consortium, expects to bring on stream in 1983.

The complexes of Dow and the Mitsubishi-led consortium will be closely linked. Arabian Petrochemical Co., or Petrokemya, in which Dow has a 50% share, will build an ethane cracker with an annual ethylene output of 1.1 billion lb. Some of the output will go to make high- and linear low-density polyethylene. Combined annual capacity will be 396 million lb. Petrokemya's ethylene also will go to Eastern Petrochemical—called Sharq from the Arabic for "East"—50% owned by Mitsubishi and its Japanese partners to feed a 660 million lb-a-year ethylene glycol unit and a 286 million lb-a-year conventional low-density polyethylene plant.

Unless there is a change of plans, Petrokemya's cracker will have an annual ethylene output capability of about 90 million lb in excess of local need. This raises the question as to what use will be made of the additional quantity of the olefin. There is some speculation that Dow might try to acquire it for its petrochemical complex now going up at Krk, Yugoslavia. The Saudis, however, are believed to be opposed to ethylene as such leaving the country.

The two other complexes at Al Jubail involve Exxon and Shell Oil in partnership with SABIC. Exxon's Al Jubail Petrochemical, or Kemya, will make linear low-density polyethylene in a plant designed to produce 572 million lb annually. Shell Oil's Saudi Petrochemical, or Sadaf, will make a variety of chemicals, including ethylene (1.44 billion lb per year), ethanol (618 million lb), ethylene dichloride (1 billion lb), styrene (649 million lb), together with benzene, chlorine, and caustic soda. At Yanbu, on Saudi Arabia's west coast, Mobil and SABIC are partners in a complex that will make ethylene (990 million lb), glycol, and high-density and low-density polyethylene.

Saudi Arabia will use some of the output. But a considerable proportion will be exported. According to Abdul Aziz al-Zamil, SABIC's managing director, Japan and the U.S. are expected to absorb 20% each of such exports and Europe 22%. The 38% balance will go to the neighboring Middle Eastern countries and to Africa. Concern on the part of other producers, already laboring under the dual problem of excess installed capacities and low demand, hardly will be allayed by al-Zamil's contention that the Saudi projects "will not cause disruption to world markets."

In nearby Israel, meanwhile, this is not the best of times economically and industrially. Economic growth has slowed for the past three years. Inflation continues at a triple digit rate, although lower than in 1979 and 1980. Spurred by rapidly rising payments for imports of oil and defense equipment and market problems for some Israeli exports, Israel's balance of payments deficit is widening.

One bright spot in this dreary picture is that Israel's modern, high-technology industries, which produce primarily for export, are continuing to grow. Industrial exports, excluding processed diamonds, rose 29% in 1979 to $2.6 billion, and 31% in 1980 to $3.4 billion; $1 billion of the $3.4 billion was for products based on Israel's own research and development. In the first half of 1981, industrial exports totaled $1.7 billion, up 5.4% from the same period last year.

Israel's chemical industry (including rubber, plastics, and mineral products) accounts for almost a third both of total industrial production and of total industrial exports (excluding processed diamonds in both cases). Thus, Israel exported about $1 billion in chemical-related products in 1980, about 27% of its total output of about $3.8 billion.

Despite all the problems, chemical expansion plans are going ahead. By 1985, new capacity will be completed for potash, bromine and bromine compounds, phosphates, chlorine, caustic soda, phosphoric acid, and pesticides. The target is $6.3 billion in production of chemical-related products in 1983 and about $10 billion by 1990. Of this, $1.4 billion would be exported in 1983 and $2.6 billion in 1990. This postulates annual growth rates from 1980 to 1990 of 8% in chemical production and 10% in chemical exports. □

Other Areas

Mexican buildup aims for self-sufficiency

Cracks are beginning to appear in Mexico's yellow-brick road to oil-based prosperity. The skill with which the government handles its newly emerging economic and financial problems is likely to determine whether Mexico's high-flying chemical industry continues its hectic growth pace or stagnates.

Outwardly, all signs point to a booming economy. For the past four years, economic growth has averaged 8% annually. Oil production has doubled. New construction is evident throughout the country.

But there are other, much less encouraging signs. Mexico, now the world's fourth-largest oil producer, was hit with a combination of economic punches as a result of the current global oil glut and the cut of $4.00 per barrel in the price of its oil it implemented this past summer.

As a result, Mexico lost billions in oil revenues and had to cut government spending. Its trade deficit is expected to reach $11 billion in 1981. Its foreign debt will top $60 billion this year, and next year, experts predict, Mexico will pass Brazil as the world's most indebted nation.

Through all of this, Mexico's chemical industry, especially petrochemicals, has continued to be one of the most dynamic sectors of industry, topped only by the oil industry itself.

Between 1975 and 1980, the value of Mexico's chemical output more than tripled, from $1.5 billion to $5.2 billion at current exchange rates. Through the first half of 1981, chemical production was up about 15%. Although that pace probably didn't last throughout the second half, annual output probably will increase 13%, falling just shy of $6 billion.

Not surprisingly, basic petrochemicals lead the chemical growth parade. Early indicators are that basic petrochemicals will increase 20% in value this year, followed closely by fiber intermediates at 17%.

Petroleos Mexicanos (Pemex), the government-owned oil company that, by law, controls output of basic petrochemicals, churned out 7.2 million metric tons of them last year. This year, output is expected to hit 8.3 million metric tons. Next year, with most of its new complex at La Congrejera coming on stream, Pemex probably will produce about 9.6 million metric tons of petrochemicals.

As impressive as these growth figures are, the chemical industry seems to be drifting further away from, rather than closer to, its cherished goal of achieving self-sufficiency for its domestic market and eliminating its troublesome trade deficit.

Over the past five years, growth of Mexico's chemical exports has outpaced growth of imports (an average 40% per year for exports vs. 35% for exports). Despite this, the chemical trade deficit has mushroomed from $304 million in 1975 to $1.3 billion last year. The outlook this year is worse.

Industry leaders are hoping that completion of the La Congrejera petrochemical complex and other major Pemex petrochemical projects being built or planned at Morelos, Altamira, Dos Bocas, and Laguna del Ostion, along with the heavy investment that is taking place in the secondary chemical industry, will quench Mexico's thirst for imported chemicals and will enable it to become a much more significant chemical exporter.

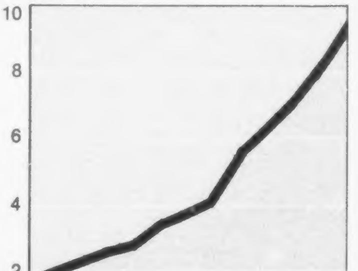
But the industry, along with much of Mexico's economy, faces some major hurdles. Price controls are cutting into return on investment. Financing is expensive and hard to come by. Transportation problems still have not been solved.

Government economic policy will dictate how successful the Mexican chemical industry will be in overcoming its problems. Will economic growth be moderated to combat inflation, or will the policy be one of full steam ahead, despite the inflationary consequences?

Compounding the uncertainty about the future is the fact that Mexico's president, José Lopez Portillo, has only one more year to serve. Then Miguel de la Madrid Hurtado will take over the president's office. Business community reaction to Madrid's selection has been favorable. But how he handles the Mexican economy may depend upon what shape he finds it in when he takes office.

Earl Anderson, New York

Mexico's petrochemical output continues to climb



a C&EN estimates. **Note:** Production of 37 primary petrochemicals produced exclusively by Petroleos Mexicanos (Pemex). **Source:** Pemex

South Korea postpones chemical expansion

South Korea's chemical industry has had to contend with at least two significant developments this year. First, early in the year it began slowly to emerge from a recession that engulfed Korea for more than a year. And second, it had to deal with sharp cutbacks and shifts in expansion plans, as the government prepares to implement the country's new five-year plan.

Korea's recession began in 1979. Gross national product, which grew 10.5% in 1977 and 11.6% in 1978, slowed to an increase of 7.1%. And last year, a disastrous rice harvest combined with the world recession, oil price increases, and political turmoil following the October 1979 assassination of president Park Chung Hee to cause an unprecedented economic contraction, with GNP down 6%.

Output of many chemicals also declined during 1980, with ammonia down about 12%, urea fertilizers 16%, complex fertilizers 15%, and insecticides 9%. Now, Korean officials predict growth in GNP of 6 to 7% this year.

This recession intruded upon two extraordinary decades of economic development. Since 1962, Korea has been transformed by four five-year Economic Development Plans from a marginally subsistent agricultural economy into one of the most advanced industrial countries of the developing world. Between 1962 and 1980, its GNP increased from $12.7 billion to $57.4 billion (at 1980 prices).

Exports provided the primary stimulus for Korea's growth and rapid industrialization, as its scarcity of natural resources and relatively small domestic market have spurred it into becoming one of the most active trading countries. Total exports soared from $55 million in 1962 to $17.5 billion in 1980.

Production and export of chemicals have shown similar growth, as Korea has built modern petrochemical, fertilizer, and textile industries. Chemical exports soared from $3 million in 1968 to $780 million in 1980.

Korea's petrochemical industry is integrated vertically around two naphtha cracking centers, one at Ulsan with 19 downstream plants and the other at Yeocheon with 15 downstream plants. They produced $1.9 million in petrochemicals last year. Originally, plans were to add further capacity and plants and to construct a third petrochemical complex, also at Yeocheon, under Korea's fifth five-year plan (1982–86).

On the other hand, Korea's petrochemical industry already is grappling with the problems of enormous cost increases for raw materials, overcapacity, and heavy inventories. It has suffered heavy losses.

In the end, the Korean government decided to postpone building the third complex and the additions, as well as other large projects. Instead, it set a slower growth target—of 7.6% annual growth in GNP from 1982 to 1986—and will divert some funds to lighter industries. Investments will go to expand capacity for synthetic fibers for the textile industry, for example.

Richard Seltzer, Washington

Taiwan to emphasize specialty chemicals

When the U.S. severed diplomatic relations with Taiwan in January 1979 and established "normalized" political relations with China, some observers wondered whether Taiwan's increased political isolation would adversely affect its booming economy and its fast expanding foreign trade. Now, almost three years later, the answer is clearly no.

On the contrary, Taiwan generally has continued its strong economic performance. Its current 10-year economic development plan (1980–89) envisions a further doubling of its real gross national product by 1989. Foreign investment continues to rise.

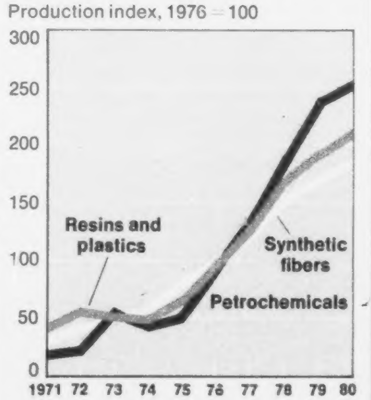
Over the past two decades, Taiwan has changed rapidly from an agricultural to an export-oriented, industrialized economy. Industrial emphasis in the 1970's passed from light industry consumer goods (such as electronics and plastic products) to backward integration into more sophisticated heavy industry, such as the petrochemical industry. Output of petrochemicals, synthetic fibers, and plastics has at least doubled since 1976. Most of the petrochemicals are exported, either directly or in processed goods.

In the 1980's, the economic development strategy will emphasize technology-intensive industries, including petroleum-based products with high added value (for example, engineering plastics and specialty chemicals and additives for the rubber, textile, plastic, pharmaceutical, agricultural, and electronic industries). In addition, under the 10-year plan, production of key petrochemicals, synthetic fibers, and plastics is to more than double—for instance, ethylene up from 420,000 metric tons in 1980 to 1.08 million in 1989. A fourth naphtha cracker, with 385,000 metric-ton-per-year capacity, is to go on stream in 1983.

However, 1980 was a relatively poor year (ethylene output grew only 5%, for example), and Taiwan's chemical industry faces several problems. Oil price hikes and the world slump in demand for petrochemical-related products have hurt. (Taiwan imports about 90% of its energy requirements.) Moreover, domestic prices of petrochemical feedstocks are much higher than world prices, endangering the competitive edge of Taiwan's downstream producers.

Richard Seltzer, Washington

Taiwan's chemical output has doubled since 1976



Source: Council for Economic Planning & Development, Taiwan

Indonesia spurs ASEAN region's rapid growth

At a time of widely slackening world economic growth, the five members of the Association of South East Asian Nations (ASEAN)—Indonesia, Malaysia, Philippines, Singapore, and Thailand—constitute the fastest growing region, economically, in the world. With a total population of more than 260 million, relative political stability, and free enterprise-oriented policies, ASEAN has increased its gross national product at an average rate of 7% a year for the past decade.

Indonesia, with a population of 150 million and rich resources of oil, gas, minerals, timber, rubber, and other materials, is by far the largest member of ASEAN. It racked up 80% of the group's balance of payments surplus last year—more than $2.7 billion—and projects a similar surplus this year. (Oil and liquefied natural gas sales constituted $17 billion of its $22 billion in exports.)

Prosperity has created a boom atmosphere. Total investment under the third five-year development plan (April 1979 to March 1984), is estimated at $69 billion, some $20 billion of it from foreign capital.

Major investments are planned for the petroleum, petrochemical, and fertilizer industries. Increased fertilizer capacity, based on abundant natural gas, already has eliminated import of urea fertilizer and made Indonesia a net fertilizer exporter. Two additional urea fertilizer plants are being built, each with 570,000 metric-ton-a-year capacity.

Overall, under the five-year plan, the industrial sector is to grow 11% a year in value added; strategic industries (chemicals, steel, and metal) are to grow 14% a year. Major projects include $3 billion for oil refinery expansion; $1.7 billion for a natural gas-based olefin petrochemical complex; $1.1 billion for a naphtha-based aromatics center; and $240 million for a natural gas-based, 1000 metric-ton-per-day methanol project.

Richard Seltzer, Washington

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Cover 1, p. 1, 6.

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Chemical & Engineering NEWS

Cover: Photo by Greg Pease

2 President's Message
4 Letters
5 Editor's Page

Concentrates

13 Business
16 Government
18 Science/Technology

The Departments

40 Newscripts

News of the Week

- ***U.S. spending for R&D*** *will hit $77.6 billion in 1982, Battelle Columbus economists say, a 12.4% rise from 1981, but most of the increase is absorbed by inflation.* ***Page 6***
- ***Henry Eyring,*** *distinguished physical chemist and former president of ACS and of AAAS, is dead at age 80.* ***Page 6***
- ***Imposing a stricter particulate emission standard*** *for lightweight diesel cars is inadvisable now, NAS panel tells Environmental Protection Agency.* ***Page 7***
- ***Richard M. Lemmon has been re-elected*** *director of the society's Region VI in a rerun of balloting.* ***Page 7***

News Focus

- ***Science adviser George Keyworth,*** *in a C&EN interview, reveals goals for reshaping U.S. science policy, touching on the tender area of research and development.* ***Page 8***

Business

- ***Pension plans for U.S. chemical firms*** *continue to contribute more funding and better financing than those of manufacturing companies.* ***Page 14***

International

- ***Computerized data-base service on chemical trade*** *gives on-line or printed statistics on some 1600 chemical products for major Western Europe trading partners as well as the U.S. and Japan.* ***Page 15***

Government

- ***Barring Congressional intervention, DOE faces the ax*** *under the President's plan to make government more efficient; most of the agency's duties likely will be taken up by Commerce.* ***Page 17***

Science

- ***Structure of palytoxin,*** *deadly poison from tropical sea animals with a chemical formula of $C_{129}H_{223}N_3O_{54}$ and a molecular weight of almost 2700, is being uncovered through NMR and x-ray methods.* ***Page 19***

Technology

- ***Deposits of massive metallic sulfides*** *in active rifts in the ocean floor near the West Coast attract prospectors for the strategically short minerals.* ***Page 21***

BATTELLE PREDICTS 12% HIKE IN R&D FUNDING

Expenditures for research and development in the U.S. will reach $77.6 billion in 1982, Battelle Columbus Laboratories says in its annual R&D forecast. According to Battelle economists Jules J. Duga and W. Halder Fisher, that amount represents a 12.4% increase from the $69.1 billion that the National Science Foundation estimates actually was to be spent for R&D in 1981.

Most of the increase will be absorbed by inflation, which Battelle estimates at 8.7% (for R&D) in 1982. The real increase thus would be 3.7%, slightly higher than the average annual 3.4% increase for the past eight years.

For a change, industry R&D funding will exceed government support. Industry is expected to provide $37.7 billion, an increase of 14.8% from 1981 and 48.6% of total R&D funding. The federal government is expected to provide $37.0 billion, a 13.3% increase and 47.7% of the total. The rest will come from academic institutions ($1.7 billion, 2.2% of the total) and other nonprofit organizations ($1.1 billion, 1.5% of the total).

Industry will continue to do most of the work. In 1982, Battelle says, performance of R&D by industry is expected to rise to $55.0 billion, or 70.8% of the total. In-house federal research will amount to $10.1 billiion (13.0%). R&D by academic institutions will account for $9.7 billion (12.5%); by other nonprofit organizations, for $2.8 billion (3.6%).

Battelle notes that federal funds support R&D performance in all four sectors. About 25% goes for in-house work; almost 50% goes to industry; about 20% goes to colleges and universities; and the remainder, about 5%, goes to other nonprofit organizations. In 1982, four government agencies will account for 87.9% of total federal R&D funding.

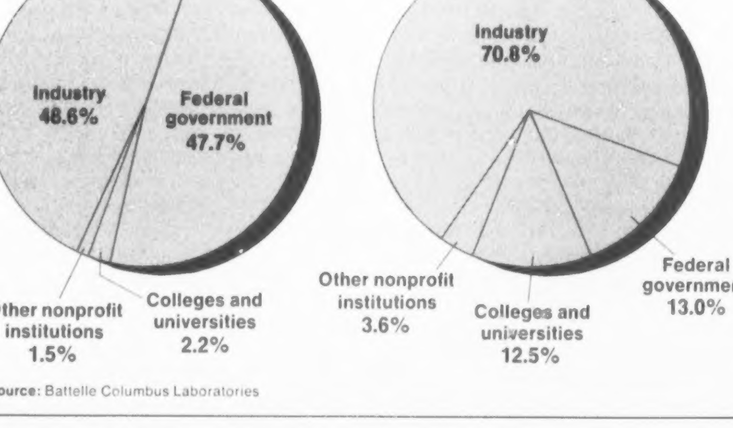
"National security, reflected in the Department of Defense budget, is the dominant driving force in furthering R&D spending," Battelle says. DOD is expected to account for 57.0% of the federal total, compared to about 45% in 1981. The National Aeronautics & Space Administration will account for 13.6% of the federal total, and the Department of Health & Human Services for 9.9%. The Department of Energy will account for only 7.4% of the total—a sharp drop from 1981's 15%.

R&D will be heavily self-funded in the manufacturing agencies, Battelle says, with, on average, only 31.8% of the $53.0 billion total coming from the federal government. Aerospace, the largest single sector, is a notable exception; the government is expected to provide 74.0% of the $12.2 billion total.

Runnerup is the electrical machinery and communications industry, with an expected total of nearly $11 billion, 41.4% federally funded. Other major sectors include machinery ($7.6 billion, 12.7% federally funded), autos and other transportation ($6.5 billion, 13.9%), and chemicals ($5.7 billion, 8.3%).

Battelle anticipates that the Administration's attitude toward business may continue to provide an atmosphere conducive to industrial R&D, with particular effort directed toward "improved competitive position vis-a-vis foreign competition." New tax credits for increases in industrial R&D also are expected to have "some small impact." □

R&D funding to reach $77.6 billion in 1982



Source: Battelle Columbus Laboratories

Henry Eyring dead at 80

Henry Eyring, the Mexican-born "cowpoke" whose talent for theory and experimentation helped elevate him to preeminence in physical chemistry, died of cancer-related illness the day after Christmas at the age of 80. He had been Distinguished Professor of Chemistry and Metallurgy at the University of Utah, Salt Lake City, since 1966.

Eyring, president of the American Chemical Society in 1963 and of the American Association for the Advancement of Science in 1965, was much admired and honored for his fundamental contributions to physical chemistry. Among his most important accomplishments are the theory of absolute reaction rate (a method used to predict theoretically the rate of chemical reactions) and the concept of the activated complex.

In more than 600 scientific papers, he described the fruits of his wide-ranging investigations in reaction kinetics, quantum chemistry, theory of liquids, optical rotation, molecular biology, aging and cancer, anesthesiology, and other areas.

Eyring's achievements were recognized with a string of honorary degrees and prestigious awards, including the Priestley and Gibbs medals and the National Medal of Science, the highest honor the U.S. can bestow on a scientist.

Born in Chihuahua, Mexico, to a well-to-do rancher, Eyring studied

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Cover 1, p. 1, 13-16.

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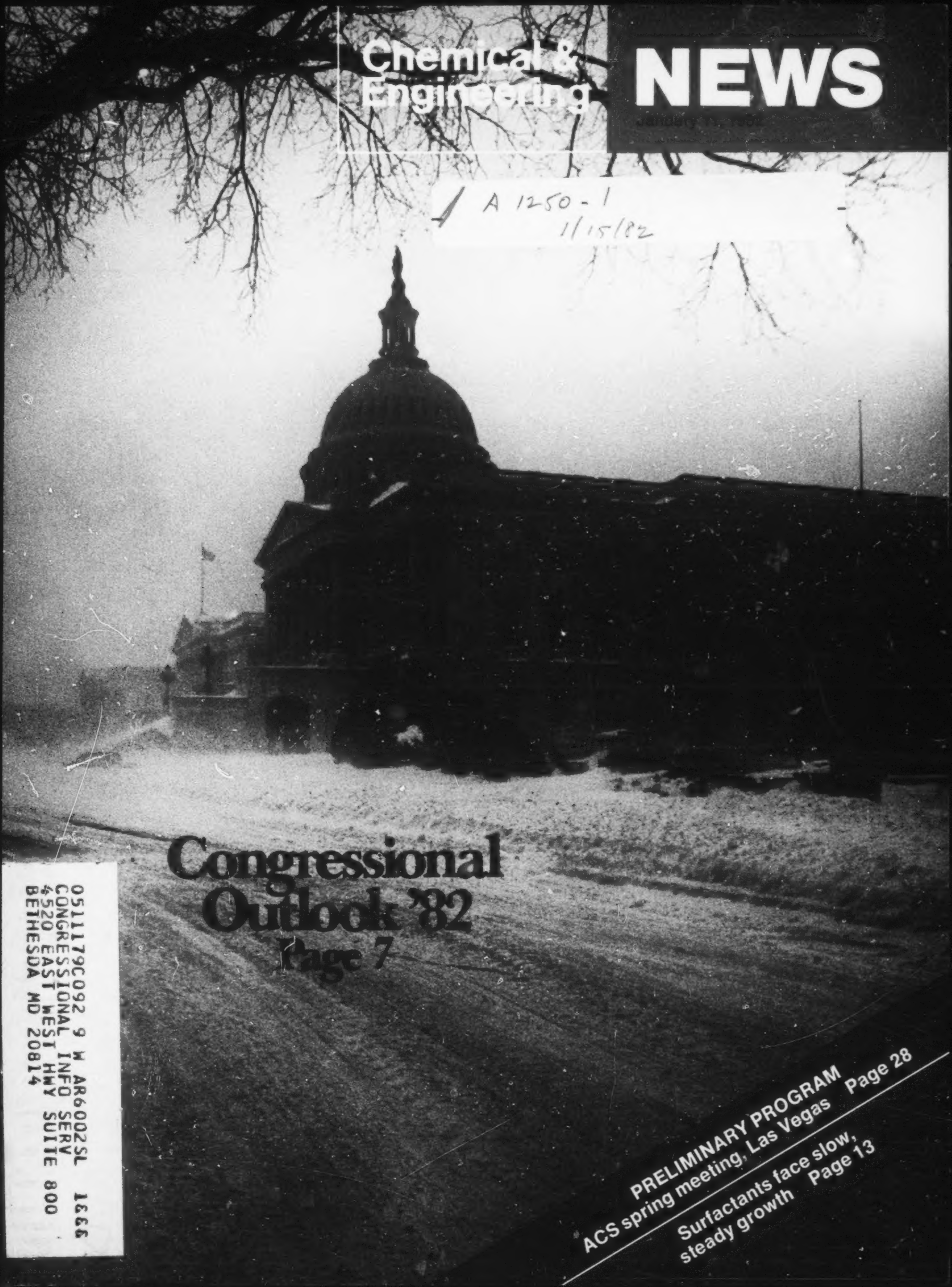

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Congressional Outlook '82
Page 7

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PRELIMINARY PROGRAM
ACS spring meeting, Las Vegas Page 28

Surfactants face slow,
steady growth Page 13

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Chemical & Engineering NEWS

Cover: Photo by Fred Maroon

2 Letters
3 Editor's Page

Concentrates

12 Business
20 Government
21 Science/Technology

The Departments

38 ACS News
38 People
50 Newscripts

News of the Week

- ***Contract negotiations*** *between oil refinery members of OCAW and oil companies are under way but the parties are far apart on wages and other benefits.* **Page 4**
- ***Chemical trade and scientific exchanges*** *will be affected little by President's sanctions against the U.S.S.R.* **Page 4**
- ***Former NIH director Donald Fredrickson*** *speaks out on NIH's efforts to cope with the recombinant DNA controversy.* **Page 5**
- ***Arkansas law*** *mandating balanced treatment for creationism and evolution struck down in federal court.* **Page 5**
- ***Occupational safety and health movement*** *predicted to become quieter with less emphasis on regulation.* **Page 6**
- ***R&D budgets for fiscal 1982 are shrinking*** *in terms of real dollars in all areas but defense.* **Page 6**

News Focus

- ***97th Congress' second session*** *likely will be dominated by economic issues and Administration may find stronger resistance to its programs as Democrats and Republicans alike face an election year.* **Page 7**

Business

- ***Surfactants market is big and mature***—*7 billion lb in 1980 and growing about 2% per year—but the industry could be in for some surprises.* **Page 13**

International

- ***New textile trade protocol*** *has been agreed to at GATT's Geneva headquarters; concern remains among EEC countries about effects of imports.* **Page 19**

Technology

- ***Microencapsulation technique*** *for producing monoclonal antibodies developed by Damon Biotech is less expensive, simplifies isolation and purification, and doesn't require the use of laboratory animals.* **Page 22**
- ***Pressurized filter*** *provides for continuous cleaning action enabling clarification of process liquids with solid contents as high as 2000 ppm.* **Page 23**

Books

- ***"Cosmic Dawn—The Origins of Matter and Life"*** *by Eric Chaisson paints a big picture of cosmic evolution and ends on an optimistic note for the future.* **Page 24**
- ***Prudent handling of hazardous chemicals*** *in the lab is subject of a manual put together by NRC's Committee on Hazardous Substances in the Laboratory.* **Page 25**

Preliminary Program

- ***The society's spring national meeting*** *in Las Vegas will have more than 260 technical sessions; information on registration, housing, and special events, and coupon for advance registration are provided.* **Page 28**

Surfactants—a mature market with potential

Growth in surfactants' use has been slow for long time, but there may be some surprises: enhanced oil recovery may be big market

Patricia L. Layman
C&EN, New York

It's big, it's mature, and it's marking time. That is one way to sum up the U.S. surfactant market as it works its way through the decade.

It is big, certainly: 7 billion lb in 1980, according to Colin A. Houston, president of the consulting firm C. A. Houston & Associates, Mamaroneck, N.Y. And it's expected to grow to 8.3 billion lb in 1991. That's a simple 2% year growth—the indication of a mature industry.

The general feeling among industry marketers seems to be that, with a few specialty exceptions, there is not a lot happening right now in the world of surfactants. For the time being, they say, there'll be more of the same—slow, steady growth in a business dominated by a single market (household cleaning and personal care products) and a larger but more fragmented set of industrial applications.

That's assuming everything goes along as normal, but the chances are that things won't. And with at least two potential wild cards in the deck, surfactant marketers are waiting.

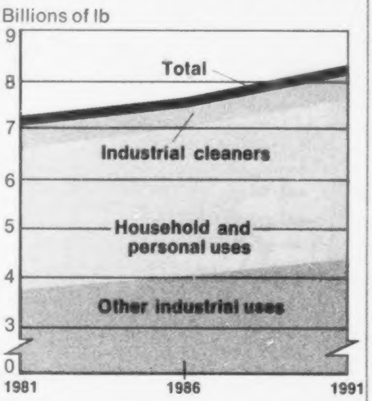
The one most people are waiting for is the prospect of a market opening up for surfactants in enhanced oil recovery. This potential market offers the promise of consuming tremendous quantities of surfactants, even more than the household-personal care segment of the market by 1990. Or it may take much less, although still a significant amount. The end of this decade will give a clearer indication of what the demand will be, but for now, it all comes down to the degree of optimism of the forecaster.

Only about 30 to 40% of the oil in a reservoir can be recovered with present conventional technology, even using water flooding. That leaves a powerfully attractive target still in the ground, and surfactants are high on the list of potential alternative methods for oil recovery. In 1979, consultant Houston estimates, only about $105 million worth of chemicals, including services, were used in oil-field processing for tertiary, or enhanced, recovery.

But surfactant suppliers are hoping for big growth for the enhanced recovery technology, which involves variations on a theme of pumping surfactant solutions down into a well formation to scrub out oil from formation rock and basically push the oil, now mixed with water and surfactant, to a producing well.

That's the theory, and, indeed, it does work, initial tests indicate. But it is an uncontrollable process. One major oil company, for example, terms its tests a failure. "We know the oil moved," reports a marketing manager, "but we never could find where it moved to."

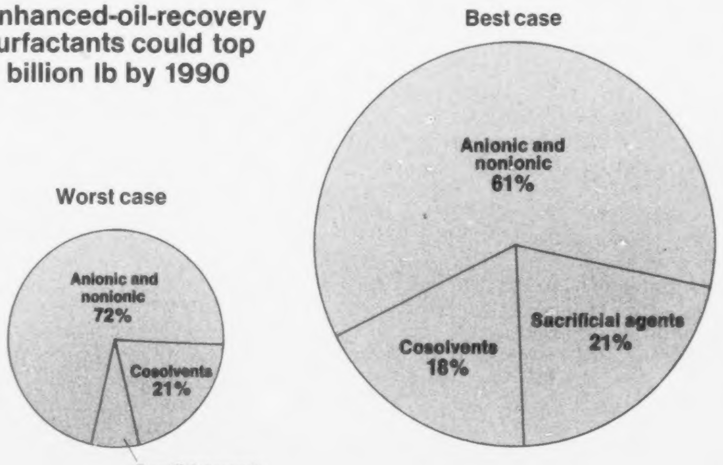
U.S. surfactant output will grow slowly next decade



Source: C&EN estimates

Nevertheless, surfactant marketers predict that the technology will become increasingly important, particularly in the form of micellar-polymer flooding. In this technique, water is pumped into a reservoir to flush out undesirable ions, using sacrificial agents such as lignosulfonates, nitrilotriacetic acid, or inorganic phosphates. Surfactants then are injected to scrub oil from the rock, polymer-thickened water is added to push oil and surfactants out of the rock, and a final injection of more water moves the whole mess to producing wells. Major surfactants presently used are petroleum sulfo-

Enhanced-oil-recovery surfactants could top 3 billion lb by 1990



Source: Colin A. Houston & Associates

Nonionics: Shell leads in higher-priced products

Nonionic surfactants, led by 12- to 18-carbon alcohol ethoxylates, got their big boost from another segment of the chemical industry—synthetic fibers. As more and more synthetics made their way into the typical laundry, detergent makers discovered that anionic surfactants, a whiz at the hot-water cleaning of cottons, are not as effective at the lower temperatures recommended for laundering synthetics. Nonionic surfactants are effective at lower temperatures, and also tend to be more effective on oily dirt—body oils, for example—and they started making their way into household detergent formulations.

Additionally, nonionics—by definition an ionically neutral compound consisting of an organic hydrophobe containing, usually, adducts of ethylene oxide— tend to be somewhat resistant to hard-water ions. So when phosphate builders were banned from household detergents in some areas of the country, areas which ironically usually had hard-water supplies, and less-effective sequesterants were formulated into products instead, nonionics gave good performance. They won't interact with other components of a formulation, such as cationic fabric softeners. That way formulators can build more complex products that can offer a consumer or industrial customer better performance.

Processing of nonionic surfactants can present problems, because they don't spray-dry well. But they are easier to incorporate into liquid detergents than are anionic surfactants, so nonionics also got a boost by the rise in popularity of heavy-duty liquid detergents. From a market niche quietly occupied by Lever Brothers' Wisk, back in the 1950s, the market took off in 1970. Liquids then had about 4% of the household detergent market; now they hold almost 20%.

Most nonionic-surfactant capacity is merchant, as is that for raw materials. Procter & Gamble is one of the major captive producers of detergent alcohols, for example, but even that detergent maker hints that its present expansion also may aim at products for lubricant additives and chemical intermediates—which might or might not be captive.

C_{12+} alcohols

	Capacity[a]
Shell Chemical	550
Ethyl Corp.	210
Conoco	135
Procter & Gamble	120
Sherex Chemical	20
TOTAL	**1035**
PRICE	**68 to 72 cents/lb**

Alcohol ethoxylate

	Capacity[a]
Shell Chemical	600
Union Carbide	150
DeSoto	100
Conoco	95
Texaco	85
TOTAL	**1030**
PRICE	**56 to 57 cents/lb**

Ethylene oxide

	Capacity[a]
Union Carbide	2170
Dow Chemical	710
Shell Chemical	700
Texaco	700
Celanese	250
TOTAL	**4530**
PRICE	**32 cents/lb**

Alkylphenol ethoxylate

	Capacity[a]
Rohm & Haas	80
Schenectady Chemicals	70
Borg-Warner	60
Monsanto	45
Texaco	35
TOTAL	**290**
PRICE	**51 to 52 cents/lb**

[a] Millions of pounds per year. **Source:** SRI International

nates, but more specialized or tailored surfactants, including naphthalene sulfonates, and alcohol and alkylphenol ethoxylates are beginning to be used, adds Houston, who predicts a "base case" 1990 market of 635 million lb of surfactants for enhanced oil recovery—and an "optimistic case" of about 3.13 billion lb.

The other wild card—for the household detergent side of the business—is NTA, the trisodium salt of nitrilotriacetic acid. In the early 1970s, it seemed to be the major contender to replace sodium tripolyphosphate, then under attack as a contributor to waterway eutrophication. But environmental questions regarding carcinogenicity arose, and at the request of the U.S. Surgeon General, detergent makers voluntarily dropped use of NTA. However, after exhaustive tests—one supplier grumbled that NTA was "the most thoroughly tested consumer chemical" he knew—the Environmental Protection Agency in 1980 gave the compound at least a lukewarm bill of health, declaring that, at least for the time being, it saw no reason to regulate NTA (C&EN, June 2, 1980, page 6).

With that encouragement, detergent makers turned their attention back to NTA, which not only is an efficient sequestrant of hard-water ions, but also is cost-competitive with phosphates. Procter & Gamble is testing several NTA-built versions of Tide and Oxydol—at present in nonphosphate areas.

And that, in turn, some marketers predict, may have a substantial impact on the surfactants used in heavy-duty powder and liquid household detergents. One possible negative impact is that, to overcome some of the performance deficiencies with nonphosphate formulations that sometimes showed up, manufacturers boosted the concentration of surfactant—to overwhelm the water-hardness ions, in effect. If NTA can be used, it might permit a decrease in the concentration of surfactant in a formulation.

Or, its use might mean a shift in the surfactants used. SRI International, for example, predicts that use of NTA will allow manufacturers to turn to less-expensive surfactants that are highly sensitive to hard water. That, in particular, would mean alcohol sulfates, made and used by Procter & Gamble. SRI suggests that tallow-based alcohol sulfate suffered in performance in nonphosphate areas, which also happen frequently to have hard water supplies. Thus concentrations of alcohol sulfates were either reduced or eliminated in products sold in those areas. Alcohol sulfates already have been reintroduced to Procter & Gamble formulations built with zeolites, which had improved the sequestering action. If NTA, an even better builder, is used on a big scale, it will mean even more demand for alcohol sulfates, much beyond the 78 million lb expected to be used in laundry powders in 1984. Consumption in 1980 was an estimated 68 million lb.

Procter & Gamble has used tallow alcohol sulfates since the late 1930s. But natural sources for surfactant raw materials have become a modern topic again, as suppliers eye stocks of coconut oil, palm oil, and tallow for their alcohols.

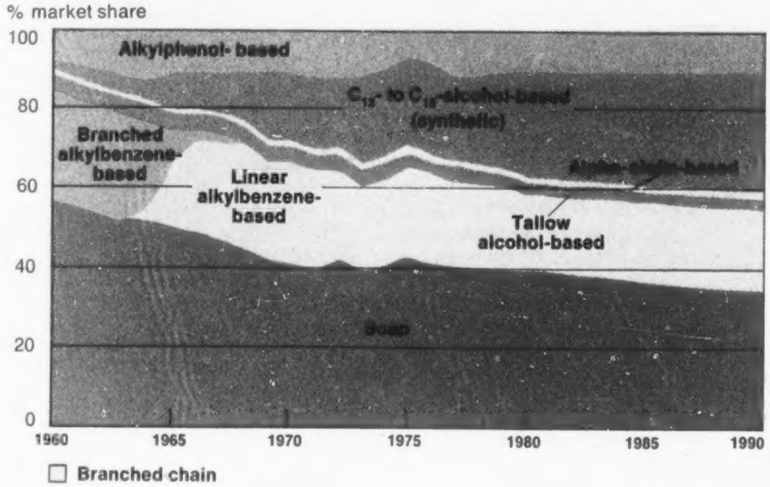
The industry basically splits into two factions, one headed by Shell Chemical and the other by Conoco. Shell, with its 550 million lb-per-year plant fed by petrochemicals for detergent alcohols (54% of U.S. detergent alcohol capacity), is sticking solidly with synthetics. Ethyl Corp., with 200 million lb per year of synthetic capacity, and Conoco, with 135 million lb, also are strong boosters of petrochemical-fed supplies.

But Conoco is hedging its bets. It is planning a 100 million to 120 million lb-per-year plant, to go on stream in 1984 or 1985, fed with natural oils. That plant is similar in size to the one Union Carbide and Henkel are planning for 1984, using Henkel technlogy. And Procter & Gamble, with 120 million lb of annual capacity using coconut oil, palm oil, and tallow, is expanding by another 65 million to 75 million lb per year. The remaining detergent alcohol producer, Sherex Chemical, is standing pat at 20 million lb.

More secure, though, is the promising outlook for alpha-olefin sulfonates (AOSs), with the fastest growth rate predicted for major surfactants. For years, AOSs were referred to as "the next generation" of surfactants, but they went through some rough times before starting what looks like a solid growth phase. Introduced for detergents in 1969, AOSs were used that year at a level of about 14.3 million lb. Then Colgate-Palmolive formulated AOSs into its Palmolive dishwashing liquid, and by 1975, these compounds were being consumed at a rate of nearly 36 million lb a year. In 1976, however, Colgate reformulated, removing AOSs. The major reason was economics, but some environmental health questions also were raised, coming from tests run in West Germany on AOSs' precursors. Use of AOSs dropped to 23 million lb in 1976, and within another year was down to 10 million lb—where it has stayed until recently.

From a solid niche in personal-care products, such as shampoos, AOSs have moved strongly into another shampoolike formulation—the so-called liquid soaps. (The term is a misnomer because the formulations are synthetic detergents.) With a start from smaller manufacturers such as Jovan's Yardley unit and Minnetonka, liquid soaps have cap-

Synthetic alcohols will make biggest gains in market



Source: Shell Chemical

Specialty surfactants: where the action is

For producers of commodity or semicommodity surfactants, the problem lies in meeting the shipping and specification demands of what is generally a few major customers. For producers of specialty surfactants, however, it's a true specialities business: many different customers, many different markets, small volumes tailored for specific end-uses, and prices on the high side.

Compared to an overall industry growth rate of 2 to 3% annually, specialty surfactants are featuring growth rates of 8 to 10% per year over the next few years. And producers figure that prices start at about 80 cents per lb, running up toward $5.00 per lb, on a 100% active basis. Competition rests on good products, but even more important, on technical service. Companies have to develop the ability to listen to customers and tailor or modify surfactants to solve their problems in order to succeed. As with other specialty chemicals, service is all-important in marketing small-volume surfactants. Thus, while prices are high, the cost of selling is also high.

Instead of large or potentially large markets, marketers seek out niches. One marketer, for example, says his firm looked at supplying the enhanced oil recovery business, but then decided "You can't beat the big boys." Instead, specialty producers have turned to areas such as emulsifiers for cosmetics, flowing and wetting agents for agricultural chemicals, wetting agents for textile processing, and rubber-processing aids.

The cast of characters is different than that for commodity surfactants. Cationic surfactants are produced by companies such as Onyx, Lonza, Armak, and Sherex Chemical for applications ranging from hospital germicides to fabric and shampoo conditioners. Amphoteric surfactants, which tend to be exceptionally mild and nonirritating, are made by Mona Industries, Miranol Chemical, and American Cyanamid, in particular. And in the larger, specialty surfactants segment of the business, companies such as BASF Wyandotte, ICI Americas, GAF, Rohm & Haas, Emery Industries, and Diamond Shamrock frequently pop up, as well as a host of other, smaller producers.

As one market manager puts it, in the overall surfactants business, there are 700 different products, 200 different producers, and 450 different end-uses. That makes for a lot of company to compete for the large markets, and some awfully small niches for producers who want to single out a market for themselves.

Anionics: from workhorse to glamor entry

Although by some estimates, nonionic surfactants have nudged into first place in the household detergent and personal-care surfactant markets—the largest single grouping—anionics still have a larger share of the overall surfactants market.

Anionics, classically an organic hydrophobe on one end and an inorganic moiety such as a sulfate or sulfonate group at the other, continue to be the workhorses of the industry. Linear alkylbenzene sulfonate (LAS) is still used in most of the major brands of household detergents, for example. Lignosulfonates, obtained mostly from spent pulping liquor of sulfite pulping operations, is a commodity surfactant, although "specialty" derivatives are used for such applications as concrete admixtures and drilling muds. And soap still accounts for some 35% of the market for major surfactants, used both in household products (primarily toilet soaps) and for industrial applications.

Most LAS is produced for captive consumption by Procter & Gamble, Colgate-Palmolive, Lever Brothers, and Purex. Stepan Chemical and Onyx are among the major merchant sulfonaters, with a host of companies both sulfonating and sulfating a variety of commodity and specialty surfactants. Sulfonation capacity generally is inclusive, because a producer can process, with a few modifications, a number of raw materials. The sulfonation technology, developed by companies such as Chemithon and Lion, is reasonably easy to adopt, and this has encouraged small manufacturers to enter either captive or merchant production.

The sulfonation of alpha-olefin sulfonates (AOSs) is an exception. Although more companies (who already have sulfonation know-how) are entering the market, it still tends to be a specialized, and tricky, business. Some marketers feel that, in turn, has tended to limit the use of AOSs in formulated products; customers might be reluctant to commit themselves to purchasing AOS surfactants when they have produced other surfactants themselves and switching to buying rather than producing could mean idling already installed capacity.

AOSs are still a small segment of the business. The alpha-olefin capacity shown, for example, aims at markets far larger than the surfactant market, presently less than 20 million lb per year; it more likely aims instead at comonomers for linear low- and high-density polyethylenes, and at other specialty markets including synthetic lubricants.

Alpha olefin

	Capacity[a]
Ethyl Corp.	800
Shell Chemical	600
Gulf	200
Chevron U.S.A.	90
TOTAL	**1690**
PRICE	**37 to 42 cents/lb**

Linear alkylate

	Capacity[a]
Conoco	375
Monsanto	240
Union Carbide	160
Witco Chemical	45
TOTAL	**820**
PRICE	**44 to 45 cents/lb**

Sulfonated/sulfate surfactant

MAJOR LAS PRODUCERS	Capacity[a]
Procter & Gamble	570
Stepan Chemical	200
Colgate-Palmolive	190
Lever Brothers	170
Purex Industries	130
Onyx	100
TOTAL	**1360**
PRICE	**54 cents/lb**

MAJOR AOS PRODUCERS	Capacity[a,b]
Stepan Chemical	200
Onyx	100
Witco Chemical	60
Alcolac	39
Detergents Inc.	28
Henkel	25
TOTAL	**452**
PRICE	**28 cents/lb**

a Millions of pounds per year. **b** Includes LAS, other surfactants. **Source:** SRI International

tured 15 to 20% of the toilet soap market. That's enough to lure even the majors. Procter & Gamble, for example, is testing a liquid, dubbed Rejoice, in Texas. And although not all the liquid soaps contain AOSs, that still has been enough to give a boost to the products, to 12 million lb in 1980 and 13.6 million in 1981.

At present, use of AOSs is mostly limited to personal-care products. The environmental-health charges were laid to rest when the original test results were chalked up to what generally was agreed to be sloppy chemistry. But olefin makers point out there are some problems with interaction with sodium hypochlorite bleach—which has tended to keep the surfactant out of heavy-duty laundry products. That is expected to be resolved, however, with AOSs' moving into laundry powders. One supplier notes that the leading brand of detergent in Japan, marketed by Lion Co., is based on AOSs. And Lion technology will be the basis of a new sulfonation unit being built by Detergents Inc., Santa Fe Springs, Calif., scheduled for completion April 1. It will have about 28 million lb-per-year capacity for processing not only AOSs but linear alkylbenzene sulfonate and alcohol sulfate.

For surfactant makers, another problem has arisen that may leave them with a sense of deja vu: biodegrability, involving branched-chain alkylphenol (primarily nonylphenol) ethoxylates. By what one supplier calls "a gentlemen's agreement," use of the alkylphenol ethoxylates had been limited primarily to industrial applications, in which wastewater could be treated without discharge into the waterways. That harks back to the mid-1960s when the industry was pressured into switching from hard, branched-chain alkylbenzene sulfonates to the softer, more biodegradable, linear alkylbenzene sulfonates. The branched-chain material didn't readily biodegrade, and it began showing up as unesthetic foam in some water supplies.

The branched-chain alkylphenol ethoxylates have about the same biodegradability characteristics as the hard alkylbenzene sulfonates—that is to say, not much. But they are also quite a bit less expensive than either linear alkylbenzene sulfonates or alcohol ethoxylates, and that has been appealing to some of the smaller, economically hard-pressed detergent makers. They have been turning to alkylphenol ethyoxylate, incorporating it into their formulations. The result? Alcohol suppliers have seen at least a tiny segment of their market eroding and, concerned that larger detergent makers also may switch to alkylphenol ethoxylates, have raised the issue again. □

NOTE

ONLY THE FOLLOWING PAGES OF THIS

PUBLICATION HAVE BEEN FILMED

Cover 1, p. 3, 33-34, 36,

38, 49-50, 52, 73, 75-76,

79.

Chemical & Engineering NEWS

Forces mobilize to combat "creation science" Page 12

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Chemical companies' R&D budgets sail through recession Page 33

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Chemical & Engineering NEWS

Cover: Monsanto scientist works on phosphorus biodegradation at company's research center in St. Louis

4 Letters
7 Editor's Page

Concentrates
30 Business
44 Government
56 Science/Technology

The Departments
70 New Products
85 ACS Comment
110 Newscripts

News of the Week

- ***OCAW has settled for less than it wanted*** *in wages, other benefits in contract negotiations with oil companies, hinting at what other unions will face.* ***Page 8***
- ***Inner-city children are at higher risk to lead exposure*** *than the general child population, national survey confirms.* ***Page 9***
- ***GAF has completed*** *the bulk of its corporate reorganization with the sale of its reprographic business.* ***Page 9***
- ***Organizational changes at the National Cancer Institute*** *mark shift in emphasis in several basic science programs.* ***Page 10***
- ***Unusual drug for treating depression,*** *made by Mead Johnson, has been okayed for marketing by FDA.* ***Page 10***
- ***Imperial Chemical Industries is buying*** *all of Rubicon Chemicals, which has been a joint venture of ICI and Uniroyal.* ***Page 10***

News Focus

- ***Creationism is under attack*** *by scientists and educators to prevent it from being taught as science.* ***Page 12***

Business

- ***Chemical firms plan 17% hike in R&D funding*** *this year to $2.62 billion following $2.24 billion in 1981.* ***Page 33***
- ***Reinforced plastics market*** *appears to be on the upswing again.* ***Page 36***

Government

- ***Cooperation, setting of realistic goals*** *are best approach to FDA problems, says Commissioner Arthur Hayes Jr.* ***Page 45***
- ***Detailed look*** *at the state of technical world is offered in NSF study.* ***Page 49***

Science

- ***Normally unreactive hydrocarbon bonds*** *can be activated to lose hydrogen in soluble metal complexes.* ***Page 59***
- ***Structure of specialized cells in eye's lens,*** *including family of unique proteins, is being explored.* ***Page 63***

Technology

- ***Public acceptance of nuclear power is declining*** *and government must consider new attitudes, social scientists say.* ***Page 73***
- ***Samples of coal*** *from three beds are available from repository for study.* ***Page 79***

Books

- ***"From Chance to Purpose: An Appraisal of External Human Fertilization"*** *discusses issues of test-tube fertilization.* ***Page 81***

ACS News

- ***Chemical Abstracts,*** *marking its 75th anniversary this year, today monitors some 12,000 scientific journals.* ***Page 86***

Company R&D budgets set for robust 1982

As recession continues, U.S. chemical firms plan strong 17% increase in R&D funding this year after higher than expected 21% gain in 1981

William F. Fallwell
C&EN, Washington

As the U.S. recession has deepened in the past few months, chemical companies have put a lot of budgets under the microscope for a second look. Some funding plans such as capital spending (C&EN, Dec. 14, 1981, page 13) wound up notably trim. But one budget area, research and development, has survived the ordeal in exceedingly strong shape.

It's almost as if hard times, plus an austerity program from the federal government, have convinced companies to plow even more of their scarce dollars into work aimed at new markets in the future. There's more to it than that, however. A combination of forces is boosting R&D: the promise of brand new products, especially in biochemistry; heavier commitments to meet new regulations; new federal tax incentives; foreign competition; and a new-found corporate urge for premium-priced, high-value-added products for the 1980s as commodity chemicals face rough times.

The result is an extraordinary surge in R&D support in the basic chemical industry, which more than most manufacturing supplies its own R&D funds. Although the recession is eroding profits, and R&D costs directly affect profits, chemical R&D budgets are due a fourth straight year of growth well above inflation. Since salaries are by far the largest part of R&D costs, such growth translates into continued expansion in R&D staffs and projects. The corporate job market for R&D professionals will stay bright.

Specifically, C&EN's annual R&D budget survey for the largest basic chemical companies finds an overall worldwide 17% increase in initial estimates for 1982 from 1981. The 15 companies in the survey plan $2.62 billion in R&D support this year after $2.24 billion last year.

This gain follows a larger than expected 21% increase in R&D funding in 1981 from $1.85 billion in 1980. A year ago, these companies expected an increase of 14% in 1981 (C&EN, Jan. 19, 1981, page 26).

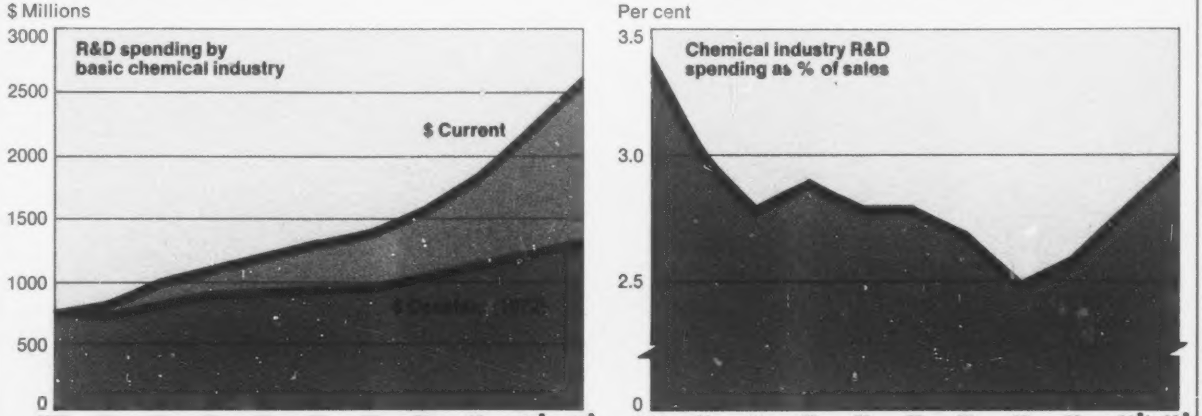
Although a few companies are making spectacular, possibly one-time, increases in R&D money, the industry's gain is not especially skewed by these cases. The upsurge runs across the board among companies with nearly all in C&EN's survey showing double-digit increases for both 1981 and 1982.

Since inflation affecting R&D, in data supplied by Battelle Columbus Laboratories, remains in single digits (7.7% in 1982 after 9.3% in 1981), every company in the survey will have real growth in R&D this year. As a group, these firms are propelling R&D funding at more than twice the inflation rate.

One result is that companies' R&D budgets finally are moving up again in relation to sales. After falling from 4.0% of sales in the late 1960s to a low point of 2.5% in 1979, R&D budgets have picked up three years in a row. This year, R&D funding has a good chance to reach 3.0% of sales, a level not seen since 1973.

Professional employment in R&D will show the effects with another solid gain. C&EN's latest employment survey (C&EN, Oct. 19, 1981, page 50) finds companies planning a net expansion of 2% for chemists and 4% for chemical engineers from mid-1981 to mid-1982.

The cumulative effect of the chemical industry's R&D renaissance in the past several years is striking.



R&D budgets rise well above inflation rate in 1982 . . .

. . . and probably will pick up again as a percentage of company sales

a Estimates. **Sources:** C&EN survey, Battelle Columbus Laboratories

Every company plans substantial boost in R&D funding in 1982 after sizable gains in 1981

$ Millions	Worldwide R&D spending: Planned 1982	Actual 1981	Planned 1981	1980	1979	1978	1977	1976	Change from previous year: 1982	1981	R&D spending as % of sales: 1981	1980
Air Products	$ 35	$ 32	$ 32	$ 30	$ 24	$ 23	$ 24	$ 19	9%	7%	2.0%	2.1%
Akzona	34	30	33	28	25	23	20	18	13	7	2.4	2.7
Allied Corp.	190	148	137	105	70	56	51	40	28	41	2.3	1.9
American Cyanamid	180	160	160	142	124	108	96	83	13	13	4.4	4.1
Celanese	118	105	105[a]	94	92	83	77	70	12	12	2.7	2.8
Diamond Shamrock	64	52	60	50	42	36	29	24	23	4	1.5	1.6
Dow Chemical	525	457	370	314	269	232	203	188	15	46	3.8	3.0
Du Pont[b]	670	575	535	485	415	377	367	353	17	19	3.8	3.6
W. R. Grace	65	51	54	45	42	37	32	28	27	13	0.8	0.7
Hercules	66	58	57	53	47	40	37	35	14	9	2.1	2.1
Monsanto	260	230	230	204	161	136	132	114	13	13	3.2	3.1
Pennwalt	34	28	28	26	24	23	21	19	20	8	2.3	2.2
Rohm & Haas	90	75	73	67	54	49	45	43	20	12	3.8	3.9
Stauffer Chemical	62	51	52	44	37	34	33	29	22	16	2.8	2.6
Union Carbide	222	186	188	166	161	156	156	143	19	12	1.8	1.7
TOTAL[c]	**$2615**	**$2238**	**$2114**	**$1853**	**$1587**	**$1409**	**$1323**	**$1206**			**2.8%**	**2.6%**
ANNUAL CHANGE	**17%**	**21%**	**14%**	**17%**	**13%**	**7%**	**10%**	**9%**				

a C&EN estimate. b Excludes Conoco. c Percentage figures are averages.

Since a real-dollar low point in 1973, R&D budgets have increased 75% in constant dollars and have tripled in current dollars. R&D professional staffs have grown about 20%. And corporate commitment to R&D has been transformed from vague skepticism or variable favor at many companies to rock solid support.

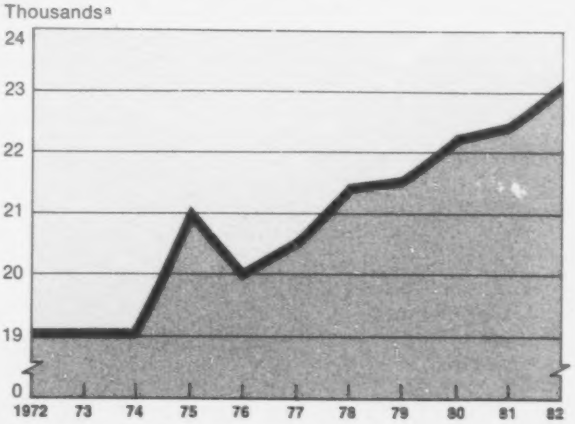
Although this boardroom appeal has been sweetened from Washington, D.C., in the past six months by new tax legislation, it is obvious from comparison with other industries that chemical companies are pushing R&D especially hard. For example, Battelle's new R&D funding survey finds an overall revised 11.4% increase by industry in 1982, 3.7% ahead of R&D inflation (C&EN, Jan. 4, page 6).

Although all chemical companies in C&EN's survey could be cited for strong R&D growth, a few stand out from a fast pack. Once more on the rise after a flat mid-1970s, Du Pont (excluding recently acquired Conoco) plans a 17% gain in 1982 to $670 million after a 19% increase to $575 million in 1981.

Not that far behind Du Pont any more, Dow Chemical expects R&D budgeting to reach $525 million in 1982 for a typical 15% gain after a one-time gain of 46% in 1981 to $457 million. The 1981 upsurge was mostly the result of Dow's absorbing its new drug acquisition from the former Richardson-Merrell.

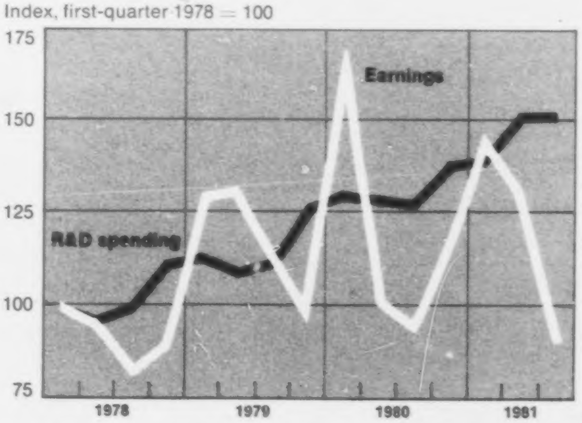
Two other companies with booming R&D budgets are Allied Corp. and Union Carbide. Allied's R&D is, in terms of per cent, the industry's fastest growing in the past decade, soaring sixfold to $190 million this year from about $30 million in the early 1970s. Carbide is on the move again in 1982 with a planned R&D increase of 19% to $222 million after small growth in the previous five years. □

Companies continue steady rise in professional R&D staffs . . .



a Full-time equivalent R&D scientists and engineers in basic chemical industry at beginning of year. **Sources:** National Science Foundation, C&EN surveys

. . . as R&D funding rises smoothly, generally faster than earnings



Sources: Combined data from American Cyanamid, Celanese, Diamond Shamrock, Dow Chemical, Monsanto, Stauffer Chemical, and Union Carbide

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Hamilton Solidum, Vice President, Manufacturing, Glines & Rhodes, Inc., precious metals refiners, Attleboro, Massachusetts

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Business

Reinforced plastics on road to recovery

If reinforced plastics producers are correct, 1982 will bring them back close to 1979's record production level after a disasterous 1980 and a so-so 1981. And next year's level may even exceed the record.

A consensus of producers is that 1982 volume growth will fall short of last year's; thus demand for reinforced plastics will not hit 2 billion lb yet this year. They predict that shipments will grow 5.2% from last year to 1.92 billion lb in 1982. Last year, reinforced plastics shipments rose 7.5% from 1980 levels to 1.82 billion lb.

These figures were revealed last week at the annual conference of the Reinforced Plastics/Composites Institute of the Society of the Plastics Industry held in Washington, D.C. The figures are part of a survey of producers and others in the industry compiled by Laura Morrison of the public relations firm Morrison-Gottlieb, New York City.

According to the survey, the biggest growth category for reinforced plastics in 1981 was the aircraft industry. This market, though the smallest charted by the survey, increased 12% from 1980 to 28 million lb. Aircraft use of reinforced plastics is expected to maintain its growth lead again in 1982, climbing 10.7% to 31 million lb.

The biggest use of reinforced plastics—land transportation—had one of the slowest demand increases in 1981. This was, of course, because of the sluggish automobile market. However, in spite of the cries of woe coming from Detroit, reinforced plastics managed a 7% increase in use for land transportation in 1981 to 445 million lb. However, reinforced plastics makers see demand for their products for land transportation struggling for only a 2.7% gain in 1982 to 457 million lb.

The reinforced plastics market hardest hit by the recession has been marine uses, suffering longer and harder than other markets. Unlike the other markets, marine uses, mainly for small, recreational boat hulls, reached their peak in 1978 at 430 million lb and then declined solidly for two straight years, followed by only a 5.5% increase in 1981 to just 290 million lb. For this year, producers expect no growth in marine uses, so consumption by the end of 1982 still will be 33% less than peak demand in 1978. This is

Reinforced plastics demand in 1982 still below 1979 levels

Millions of lb	1982[a]	1981[a]	1980	1979	1978	1977	% change 1981–82	% change 1980–81	Average annual change 1977–82
Transportation, land	457	445	416	550	535	374	2.7%	7.0%	−1.0%
Marine	290	290	275	385	430	400	nc	5.5	−5.9
Construction	327	309	287	335	320	266	5.8	7.7	2.7
Anticorrosion	302	275	252	238	216	192	9.8	9.1	9.5
Electrical	196	178	162	190	170	147	10.1	9.9	5.9
Appliance	117	112	104	130	123	112	4.5	7.7	0.9
Consumer goods	118	110	103	126	116	107	7.3	6.8	2.0
Aircraft	31	28	25	23	22	21	10.7	12.0	8.1
Other	78	74	70	79	74	70	5.4	5.7	2.2
TOTAL	**1916**	**1821**	**1694**	**2056**	**2006**	**1810**	**5.2%**	**7.5%**	**1.1%**

a Estimates. **nc** = no change. **Source:** Reinforced Plastics/Composites Institute of the Society of the Plastics Industry

hardly surprising, though, because during a recession recreational markets for any product are usually the first to slip.

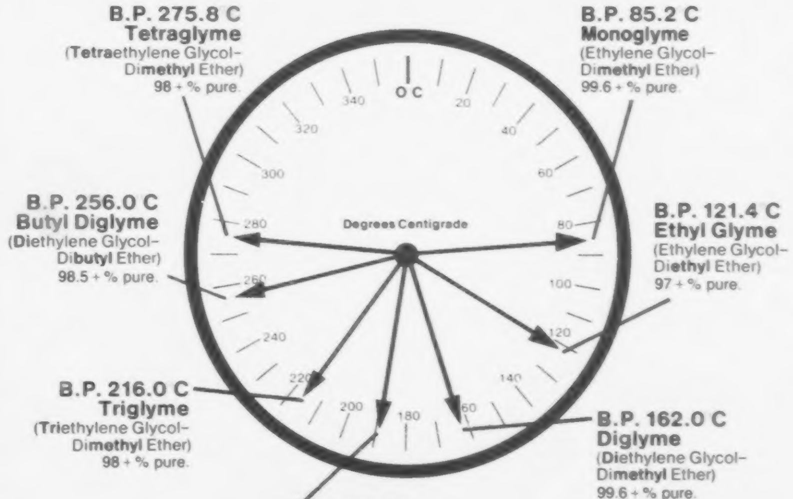
Construction uses for reinforced plastics, in spite of continued recession and high interest rates, chalked up a relatively good increase in 1981 of 7.7% to 309 million lb. However, growth in this area is expected to slow in 1982 to 5.8%, with demand likely hitting about 327 million lb.

Other than aircraft markets, the best growing outlets for reinforced plastics last year were in corrosion-resistant equipment and electrical products. Corrosion-resistant equipment uses increased 9.1% to 275 million lb in 1981, and electrical markets grew about 9.9% to 178 million lb. These two markets are expected to continue to do well this year. The survey indicates that the market in corrosion-resistant equipment may increase a further 9.8% in 1982, and that in electrical uses may rise at an even faster 10.1%

Thus, reinforced plastics, many of whose uses are closely tied to the economy and are therefore highly cyclical, are beginning to recover. But, even with a 5.2% growth this year, the industry still will be almost 7% below consumption levels in 1979, its most recent good year.

William Storck, New York

If three Glymes have 140 patented applications, think what you can do with Grant's seven Glymes.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Government

NSF study gives global technology picture

It may be anachronistic and inward looking in an age of confusing social and economic problems, but the fifth version of the National Science Foundation's "Science Indicators—1980" is out and like its predecessors, its content overwhelms.

It tells a tale of the U.S. scientific and technological giant that is big and moving on a powerful momentum. It contains little interpretation, no warnings, no social philosophy, only facts—facts in profusion.

But taken on its own terms, "Science Indicators" does offer a full diagnosis of the state of the technical world. It documents the continuing decline of American pre-eminence in technology around the world in comparison to the rise of Japan and Europe. It tells of threats, however, to Japan and West Germany through the technological buildup of such once-deficient cousins as Taiwan, Hong Kong, South Korea, Singapore, and Brazil.

It says that although the U.S. may be fading—and such terms should be hedged—in world technological competition, the U.S. stands to be the world leader for a long time to come in educating foreigners in the ways of research and development. About 300,000 foreigners currently are enrolled in U.S. colleges and universities. One significant lag the report points out is reluctance of U.S. innovators to develop capital-saving and material-saving technologies as Japan and West Germany have done, favoring instead labor-saving innovations, reflective of an affluent, abundant society.

One feature of this edition is a section on public attitudes toward science and technology, revealing a country on the whole friendly toward that view of progress. But 53% of 1635 individuals surveyed said science and technology are changing their lives too quickly. A full 65% believes scientists should not be studying ways to create new forms of life.

But 81% of what the study called "attentives"—those who claim a deep and continuing interest in scientific progress—think scientists will solve the energy problems, predict earthquakes, find the cure to cancer, and desalt seawater cheaply in the next 25 years. Fully 78% see harm in the continued development of nuclear power, and 62% don't want a nuclear power plant in their areas. Attentives, however, support nuclear power.

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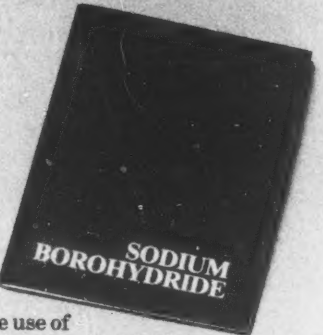

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The manpower section offers some food for thought through its report of an 8% decline in science jobs between 1976 and 1978, except for computer specialists and environmental engineers. Engineers and computer specialists are in short supply, while biological and social scientists are having relatively more difficulty finding work. "In recent years," the report says, "employment in science and engineering has grown more slowly (2.5% per year) than total U.S. employment and GNP (4% per year), indicating shifts in national activity patterns away from those related to science and technology."

Opportunities for doctorate holders in industrial jobs appear to be increasing, with industry now employing 13% of Ph.D. holders as opposed to only 10% in 1970. Highly ominous is the declining employment opportunities for young Ph.D.s in academia. The proportion of doctorate holders in science and engineering under the age of 35 in colleges and universities declined 30%. Moreover, says the report, "this decline might have been greater except that the number holding postdoctoral appointments (who are generally under 35) almost doubled."

Within the past three years or so, industry has been taking more interest in supporting and cooperating in scientific research in universities, especially in such fields as genetic research, microelectronics, and robotics. This development is not underscored in the study, but the trend toward joint industry-academic authorship is. The number of jointly authored articles increased 9% between 1973 and 1979, with biology and mathematics in the lead. In 1979, 17% of all papers authored by industrial researchers had academics as coauthors.

Yet, industrial research continued to decline in terms of output—even as industrial funding for development continued to soar. Published technical articles in eight fields declined 21% during that seven-year period, "well above the 4% drop in such publications by all U.S. authors."

The international science and technology picture is probably the most relevant to the future health of the U.S. system, and this section is loaded with factual nuggets.

America's comparative advantage in technological product output may be finding a lower equilibrium compared with the booming postwar years when Japan and Western Europe were recovering from the war. But the U.S. still sells about nine times more technology than it buys. Moreover, it vastly outspends any single competitor in research and development—$48.3 billion in 1978 compared with $46.5 billion for France, West Germany, and Japan combined.

Innovations from U.S., Europe, Japan 1945–74

Perceived advantage at time of introduction	Number	Per cent[a]
United States	**826**	**100%**
Labor-saving	331	40
Material-saving	175	21
Capital-saving	58	7
Novel function	106	13
Safety	50	6
Multiple and other	106	13
Europe[b]	**946**	**100**
Labor-saving	120	13
Material-saving	444	47
Capital-saving	104	11
Novel function	83	9
Safety	60	6
Multiple and other	135	14
Japan	**94**	**100**
Labor-saving	6	6
Material-saving	32	34
Capital-saving	7	7
Novel function	12	13
Safety	7	7
Multiple and other	30	32

a Per cents may not add to 100 because of rounding. b The nine nations included are Austria, Belgium, France, West Germany, Italy, the Netherlands, Sweden, Switzerland, and the U.K.

The picture is, more than anything, confusing. The confusion comes from observing that the U.S. remains the most powerful market for science and technology of any single country or group of regional countries in the world. It is so big and rich that it can sell to itself and leave more than enough room for imports than any other region. Compared to any other country, it is safer and less fragile as witnessed by the enormous foreign investment in land, banks, and businesses. With these facts, are the figures that display "technological decline" in the U.S. really all that relevant? The report doesn't say.

What is happening more and more is that U.S. high-technology companies are exporting their know-how, increasing R&D activity abroad, and transferring technology faster than any other international entity. U.S. investment abroad, says the study, reached $74.2 billion in 1978. The amount of R&D done by these firms reached $2.7 billion in 1979, equal to about 11% of total 1978 U.S. industrial R&D funds. On the other hand, foreign companies spent $898 million for R&D in the U.S. affiliates.

"There is evidence," says the study,

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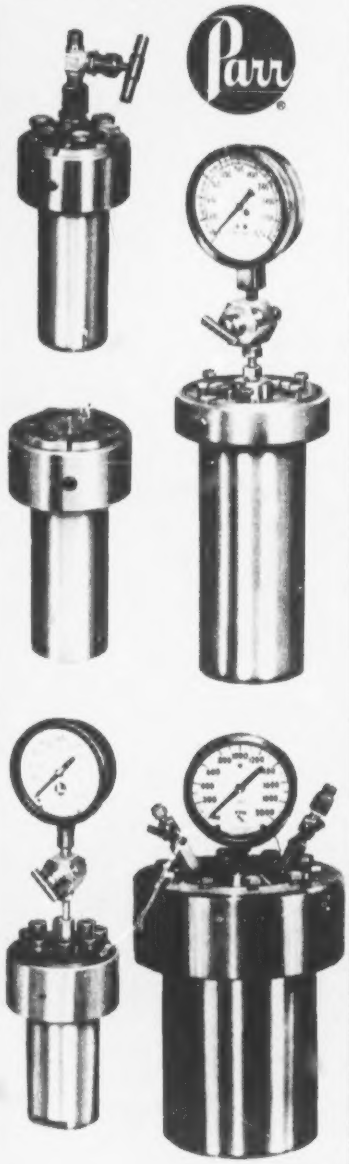

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"that the preferred mode of technology transfer, and therefore the source of technological earnings, is through U.S. subsidiaries abroad. Additionally, it is possible that U.S. innovations with a labor-saving orientation may not be as relevant to today's needs as they once were. Japanese and European capital-saving and energy-saving innovations may be more in demand."

The last point could be the key to the competitive future and was examined in only a couple of pages in the report. The phenomenon seems to indicate that Japan and West Germany have come to terms earlier than the U.S. with the era of scarcity, especially with regard to capital. It will take vast amounts of capital to open new mines, develop fusion energy, build conventional nuclear plants, and renew outmoded industrial machinery. In other words, those countries could have a sharper sense of the future than the U.S. and could be in a better position to help the U.S. than the U.S. itself if scarcity worsens in the Western Hemisphere.

No one really knows. One can only gather facts. And this is what "Science Indicators" presumably will continue to do. But are facts enough in an era of uncertainties? Shouldn't "Science Indicators" offer more of a strategic guidepost to the future or at least be related to the broader question of human welfare?

Some think it should. In a paper appearing in the current issue of *Science, Technology, and Human Values*, published jointly by Harvard and Massachusetts Institute of Technology, Robert S. Morison, visiting professor of science and society at MIT, says exactly that.

Morison says "Science Indicators" should begin with a description of social needs, followed by statistical attempts to determine how science and technology are meeting those needs. Instead, he says, "Indicators" is merely an index of how science and technology relate to themselves, or at most to technical competition.

Indicators, he says, "tell us little about the state (or 'health') of science as a whole." Indeed, Morison continues, "One begins to suspect that there is no such thing. Perhaps the best we can do is to select a series of goals and ask ourselves how close we are to each one. Those so inclined could then sum up these to produce a single global figure, although there is no reason to suppose that such a 'whole' would be any greater than the sum of its parts."

Wil Lepkowski, Washington

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Public acceptance of nuclear power declining

Reagan Administration must consider public's changing attitudes toward energy options as it tries to raise support for nuclear power

James H. Krieger
C&EN, Washington

To say the least, the past decade hasn't been kind to nuclear power. Now, however, the Reagan Administration is hoping to bring about a rejuvenation of that energy technology as part of its energy program. Whether it can or not may well depend on public opinion.

Early this month, a number of social scientists were in Washington, D.C., at the annual meeting of the American Association for the Advancement of Science, trying to read nuclear power's lifeline to see if nuclear has any hope for a brighter future. Specifically, they were examining public attitudes toward nuclear energy to see what effect those attitudes might have.

The bottom line on public acceptance of nuclear power is drawn by sociology professor Eugene A. Rosa, coordinator of the Public Opinion Laboratory at Washington State University. The public climate for the rapid expansion of nuclear power, he says, appears to be less propitious now than perhaps at any time since the immediate aftermath of the accident at Three Mile Island in the spring of 1979. Partly counterbalancing this bleak picture, however, Rosa says, is evidence showing that there is less polarization among the public over the nuclear option than is claimed by many energy experts and policy makers.

This public attitude, Rosa maintains, is something that policy makers must take into account. At one time, nuclear's problems—reactor safety design or ways of handling radioactive waste—might have been considered as being amenable to engineering solutions. But no longer.

"What was once deemed solely an issue of technological feasibility and economic advantage," Rosa says, "is now—more than ever—an issue of public acceptance." Sociologist William R. Freudenburg of Washington State University echoes the theme: "It is becoming increasingly apparent that social, political, and human value questions are at the very core of the nuclear stalemate."

If so, it may be bad news for the Reagan Administration's nuclear program. Administration budgets have included increased support for nuclear power, while at the same time reducing support for alternative sources of energy, particularly solar power and conservation. The President has announced an official Administration plan to create a more supportive environment for nuclear power, and to rehabilitate the nuclear power industry.

This approach, Rosa suggests, may be counterproductive. The evidence from analysis of public opinion surveys, he says, suggests that a national policy that emphasizes differences between nuclear power and conservation in strikingly oppositional terms seems less destined to gain public support than a policy that makes room for both options. Devoting major efforts toward nuclear power at the expense of conservation may very well prolong the high level of opposition to nuclear power.

Policy implementation cannot ignore public preferences, Rosa says, whatever the resolution of other key issues may be. Public policy makers may not be very responsive to the public mood. Nevertheless, the public climate establishes the broad boundaries within which decision makers must operate.

William L. Rankin, a research scientist at Battelle Human Affairs Research Center, Seattle, has taken a look at that public climate over time. In 1977, he and his colleagues obtained more than 100 surveys of national, state, and areawide sampling scope. Different research firms used different questions to ascertain public attitudes toward nuclear power. In general, however, Rankin notes that two types of questions were asked to probe nuclear attitudes: whether respondents generally favored or opposed building more nuclear power plants, and whether the respondents favored or opposed building a nuclear power plant "nearby" (within 5 to 20 miles of the respondents' homes). Subsequent surveys have been used to bring the longitudinal analysis up to date.

It appears, Rankin says, that general attitudes toward nuclear power remained quite stable through 1976. On a general level there was a ratio of almost 3:1 in favor. Even on the question regarding a nuclear plant nearby, the public favored such construction about 1.5:1.

An analysis of survey data collected by five national research firms from 1971–76 did not indicate any clear trend over time in support or opposition to the general question of nuclear power, Rankin says. There was some indication, however, that acceptance of local power plants was decreasing.

Since 1976, however, a great deal has happened that may have in-

Nuclear energy is least popular of alternatives

	Chosen in top three preferred		Top three minus least preferred	
Energy alternatives	SERI[a]	CEQ[b]	SERI[a]	CEQ[b]
Solar energy	66%	61%	63%	55%
Energy conservation	45	35	41	32
Synfuels	38	26	33	16
Hydropower	34	31	26	21
Coal	36	36	23	27
Oil and natural gas	34	28	22	19
Nuclear energy	27	23	−18	−10

a Data from Gallup national survey of homeowners conducted for the Solar Energy Research Institute, Oct.–Nov., 1980. b Data from Roper and Cantril national survey of adults 18 and over conducted for the Council on Environmental Quality, Jan.–March, 1980.

fluenced public attitudes toward nuclear power. An increased belief in an energy shortage and foreign energy supply disruptions may have made public attitudes more positive toward nuclear power. On the other hand, reactor accidents and continued controversy over nuclear waste management may have made attitudes more negative. In any event, the most notable nuclear incident since 1976—the Three Mile Island (TMI) accident in 1979—did have a significant effect on public attitudes toward nuclear power.

Since the TMI accident, the pattern of attitudes toward nuclear power in general has become quite variable. Opposition levels exceeded support levels in several post-TMI surveys, whereas this had never happened in pre-TMI surveys. Also, the average support, opposition, and uncertainty levels pre- and post-TMI statistically were significantly different, Rankin says. Support decreased, opposition increased, and uncertainty decreased.

For local nuclear power plant construction, support decreased while opposition increased through the 1970s, Rankin points out. Although support was stronger than opposition by about 2:1 in the early 1970s, the situation now has reversed.

Taken together, these patterns suggest that general support for nuclear power appears to be "soft," Rankin says. To gauge the strength of that general public attitude toward nuclear power, Rankin and his colleagues analyzed survey questions relating to restrictions on nuclear power: operating only those plants already built, cutting back the operation of plants, and permanently closing all plants.

This analysis, Rankin says, showed that about 75% of the public opposes permanently closing all nuclear power plants. There is less strong, but still a slight majority, opposition to closing all plants until questions of safety are answered. However, there is plurality to majority support for cutting back on the operation of nuclear power plants until more strict safety regulations can be put into place.

Rankin makes the point that to predict changes in nuclear power attitudes, it's necessary to know not only the history of those attitudes and how they've changed, but to know what beliefs about nuclear power influence those attitudes.

Analysis of surveys along this line shows that beliefs about the safety of nuclear power plants are the most important in influencing nuclear power attitudes. These, Rankin says, are followed in importance by beliefs regarding the economics of nuclear power and by beliefs about nuclear power's being a long-term reliable energy source that can help free the U.S. from dependence on foreign energy sources. Also having some influence are beliefs about nuclear power plant pollution and radioactive waste disposal.

Barbara Farhar-Pilgrim, a consulting sociologist in Boulder, Colo., probes a little deeper on some of these points. On the question of local opposition to nuclear power plants, she notes that it seems that any energy source appears a good idea until it is located nearby. Yet, she says, some are more tolerable than others.

Farhar-Pilgrim notes a 1980 national survey that measured a "tolerance distance" for five types of facilities: a 10-story office building, a large factory, a coal-fired power plant, a disposal site for hazardous waste chemicals, and a nuclear power plant. Respondents were asked the closest each facility could be built to their homes before they would want to move or actively protest.

The majority of the respondents preferred that a nuclear facility be at least 50 miles away. The mean distance preferred was more than 90 miles away—the greatest distance for any of the facilities considered. Even a controlled hazardous waste disposal site was slightly more tolerable than a nuclear power plant.

Farhar-Pilgrim also analyzed studies that asked respondents to choose from among a list of possible energy supply sources. The conclusion: Nuclear energy is by far the least favored energy source; given almost any other option, the public would choose no further development of nuclear power.

The same pattern, Farhar-Pilgrim notes, holds for types of local energy facilities preferred. Data from various studies show that nuclear facilities are the least popular type of energy facility both in the abstract and in the concrete. In particular, she says, nuclear facilities are more objectionable to local populations than are any other types of energy facilities.

For Farhar-Pilgrim, an implication of her findings is that the Reagan Administration is increasing federal

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funding for the one energy supply source that is clearly least acceptable to the American public. At the same time, government programs for the most popular energy supply sources—solar energy and energy conservation—have been cut severely.

Still, the analysis by Washington State University's Rosa indicates that the public isn't as polarized as it may appear. To get the full image of public attitudes toward nuclear power, Rosa and his colleagues turned to a particular survey and resketched the profile to allow for a broader range of energy policy positions. The survey compared nuclear and conservation attitudes. In particular, four broad classifications in policy position were made: a position favoring neither nuclear nor conservation, a conservation-only emphasis, an emphasis combining conservation with nuclear, and a nuclear-only emphasis.

This broader range of policy preferences among the public, Rosa says, provided a different picture than that obtained from an overview of survey data. One aspect of this changed picture, he says, was the sizable proportion of the public—15 to 22%, depending on stringency of criterion—favoring both the nuclear and conservation option. Another was the noticeable proportion favoring neither option—19 to 27%. Thus, Rosa points out, while a sizable proportion of the public appears to be polarized on the issue of nuclear energy versus conservation, a smaller but still sizable proportion favors both or neither.

Rosa notes that nuclear proponents differ in many ways from conservation-only proponents. They are more likely to be male, older, homeowners, longtime residents of their communities, and in the highest income category. They are less likely to see the energy situation as serious, and are somewhat less likely to favor specific conservation programs or feel they can further reduce their home energy consumption.

Large majorities of the members of all four categories favor increased development of all energy sources—in the case of solar energy, 90 to 96% across the four categories. Even persons who support neither conservation nor nuclear energy give rather strong endorsement to other energy sources. This finding, Rosa says, indicates that they are not as negatively disposed toward energy development as one might assume.

The most striking finding, Rosa says, is that regardless of policy

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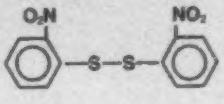

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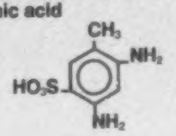

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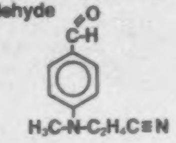

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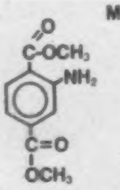

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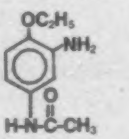

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preference, many people already have adopted or are adopting a range of conservation practices. It is even more striking, he says, to find those who prefer nuclear growth above all options likewise adopting a number of conservation practices.

Since actual practices are, to a large degree, independent of policy positions, Rosa argues, it may be that policy position reflects a general ideological orientation bearing little relationship to actual behavior. ☐

Coal samples available from repository

A coal repository, recently established at the Pittsburgh Mining Technology Center of the Department of Energy, has been made available to interested parties in industry and academia. The repository was established by the Pittsburgh center's coal preparation division to provide contractors in its chemical desulfurization of coal program with well-characterized samples so that results from different projects could be directly compared.

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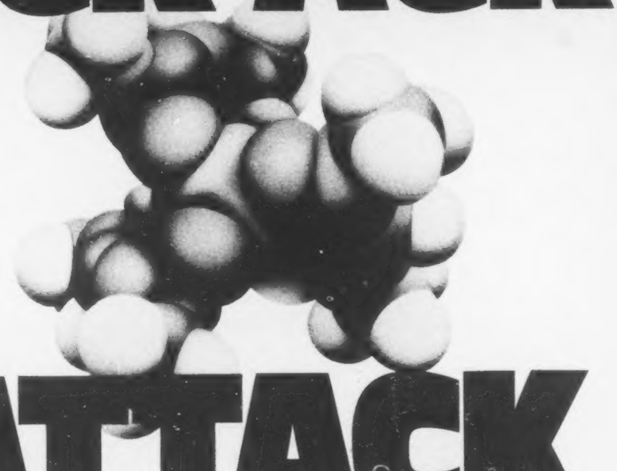

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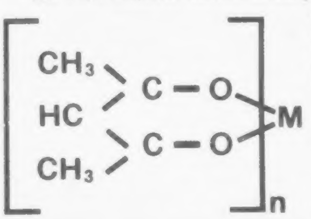

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Exports are main hope in a weak market

A Key Chemicals Review *Page 18*

January 25, 1982
Volume 60, Number 4
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Chemical & Engineering NEWS

Cover: Occidental Petroleum's vessel *Frances Hammer* carries superphosphoric acid from Florida to the Soviet Union as part of a trade agreement

4 Letters
9 Editor's Page

Concentrates

14 Business
22 Government
30 Science/Technology

The Departments

51 ACS Comment
58 People
59 Awards
61 Meetings
72 Newscripts

News of the Week

- ***OSHA proposes companies*** *conduct their own voluntary job health and safety inspections under new programs.* ***Page 10***
- ***Formaldehyde insulation trade group*** *blasts consumer agency.* ***Page 10***
- ***Tri-State Synfuels*** *wants to change process for its proposed plant.* ***Page 11***
- ***Link between certain food additives and hyperactivity*** *in children not well established, concludes NIH conference.* ***Page 11***
- ***GE testing solar collector*** *with unique high-efficiency design.* ***Page 11***
- ***Clean Air Act reauthorization bill*** *in House pleases Administration.* ***Page 12***
- ***Fourth-quarter 1981 earnings*** *are off at most chemical companies.* ***Page 12***

Business

- ***Big volume acids—sulfuric and phosphoric—enter economic doldrums*** *as poor fertilizer market curbs demand.* ***Page 18***

International

- ***Western European chemical output*** *shows little improvement over a poor 1980; slump will continue in 1982.* ***Page 21***

Government

- ***Federal funds for most R&D in fiscal 1982*** *are barely keeping up with inflation, but defense gets big increase.* ***Page 25***
- ***Growing debate over national security/science issues*** *is given focus in speech by CIA's Bobby Inman.* ***Page 27***

Science

- ***Kinds of food early humans ate*** *can be determined by using chemically based techniques on their fossil remains.* ***Page 31***
- ***Role of collagen in disease*** *is under investigation at various labs.* ***Page 32***

Education

- ***More science is taught*** *at the precollege level in Japan, Soviet Union, and East and West Germany than in the U.S.* ***Page 42***

Technology

- ***Irish firm's drug reformulation effort*** *is being expanded in the U.S. via establishment of a new subsidiary in Georgia.* ***Page 43***
- ***Nations fall short*** *in meeting global problem of ozone depletion by CFCs.* ***Page 44***

Books

- ***"Polywater,"*** *by Felix Franks, chronicles heated four-year controversy over alleged new form of water.* ***Page 47***

ACS News

- ***Official reports*** *of actions taken by ACS Board at its December meeting.* ***Page 52***

Big-volume acids join the recession

One of chemical industry's few bright spots since 1979, sulfuric and phosphoric acids now are struggling because of poor fertilizer market

Key Chemicals

The party's over for one of the U.S. chemical industry's biggest and, until recently, brightest product areas, the $7 billion-per-year big-volume acid business. And even if the party starts up again later this year, it may be strictly a milk and crackers affair. The champagne days of 1979, 1980, and part of 1981 are gone for sulfuric and phosphoric acids.

What is ruining the festivities for these two mammoth inorganics is deep trouble in their dominant use, phosphate fertilizer. A true worldwide business, phosphates first weakened in the U.S. in 1980 and then lost export momentum in 1981.

Exports are important three ways—for phosphoric acid itself, phosphate fertilizer, and the grain grown using phosphates. Right now, all three are soft enough that prices are way down. Acid producers still hope for an export pickup to save them later this year, but realistically no relief is in sight—despite the large superphosphoric acid shipments by Occidental Petroleum to the Soviet Union.

Long term, the boom years of 1979 and 1980 will be exceeded eventually, but not in 1982 and possibly not in 1983. The outlook for phosphate fertilizer is very unclear for the next several years. A mass of economic and political forces is at work, giving phosphates and their precursor acids a negative outlook at the moment.

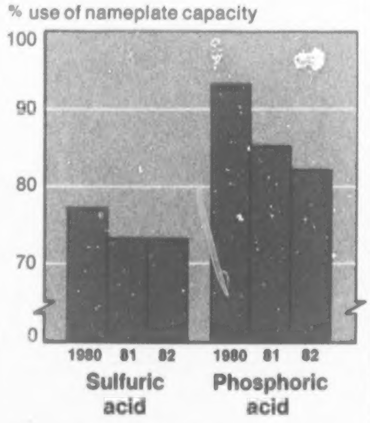
For example, the state of credit clearly influences demand for fertilizer. In the U.S., money for fertilizer is now very tight with interest rates again on the rise. Producers of the acids therefore expect little change in production rates this quarter from the low rates in late 1981. Because of the cost of money, no inventory building is expected now even though inventories are considered modest at fertilizer dealers and the peak marketing season in the spring is just around the corner.

So this spring, when acid producers expect a pickup in fertilizer demand, some sales may be lost because of a lack of inventory. That applies especially to the domestic phosphate delivery chain—the U.S. dealers who quickly supply farmers when spring weather permits. Paperwork delays generally give producers enough time to round up product for export sales. However, the sheer size of some export orders can tempt producers to divert product from domestic markets.

This year, as in early 1981, acid producers are pinning high hopes on exports of phosphoric acid and derivatives to recover from the previous year's slump. But exports depend heavily on fragile factors such as U.S. relations with the Soviet Union, debt loads in developing countries, and competition from other acid sources such as North African countries.

To date, the U.S. government has held off blocking Occidental Petroleum's sales to the Soviet Union as a sanction in the Polish crisis. The U.S. phosphoric industry assumes that no such embargo will happen.

Plant use is slipping for both big acids



Sources: Industry, C&EN estimates, Commerce Department

But in international politics, such assumptions can go wrong. Two years ago at the time of the Soviets' invasion into Afghanistan, President Carter at first let Occidental's Soviet deal continue and then suspended it. It took almost a year and a half for Soviet-bound shipments to resume. In the interim, industry analysts estimate that diversion of Occidental's production added about 5% of unwanted output to the U.S. domestic market.

The U.S. market for fertilizer also hangs importantly on exports. Longer term, as in the recent past, grain exports can boost U.S. prices, farm income, and phosphate fertilizer sales. In fact, the U.S. market for fertilizer won't grow much without exports.

Forecasting export markets is hazardous. The latest proof is the fate of U.S. plant expansions in acids and phosphates during the export boom from 1979 to early 1981. The ensuing export slump has delayed full use of large new capacity and stalled the next round of expansions.

So for some time, perhaps two years, sulfuric and phosphoric acids may languish in a holding pattern. Production volume, 56 million to 57 million tons per year of 100% H_2SO_4 and H_3PO_4, will remain below combined production of 58.5 million tons in 1980. Estimated 1982 production value will be about $7 billion, up very little from 1980 and well down in constant dollars.

This inability to increase product prices with inflation will continue to plague acid producers. The resulting profits drain will help delay all expansion programs. Based on historic plant operating levels for phosphoric acid, which can be very high, current capacity will be enough to meet demand possibly to 1985.

However, forecasts for fertilizer demand are notorious for missing the mark. A sudden surge in demand throughout the world could bring shortages, even with new plant capacity coming outside the U.S. For the moment, U.S. acid producers can hope for the unexpected but cannot count on it.

Bruce Greek, Houston, and
William Fallwell, Washington

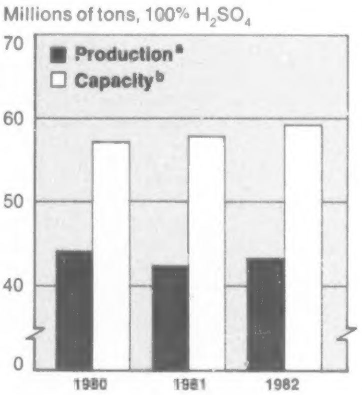
Key Chemicals

Sulfuric Acid

H_2SO_4

- ***Demand repressed***
- ***Capacity rising***
- ***Prices poor***

PRODUCTION/CAPACITY



a From all sources. b First quarter.

HOW MADE

Sulfur dioxide from sulfur or smelter gases oxidized and reacted with water

MAJOR END USES (U.S.)

Fertilizer 70%; chemical manufacture, metal recovery, and petroleum refining, each 5%

FOREIGN TRADE

Exports—rising to more than 200,000 tons in 1982, imports—holding between 300,000 and 400,000 tons in 1982, mainly from Canada

PRICES

Posted contracts, nonsmelter acid, $75 to $95 per ton (merchant sales less than 30% of production)

COMMERCIAL VALUE

$3.25 billion for production, 1982

For sulfuric acid, the king of U.S. chemicals, trends are a bit elephantine—weighty and slow. But they are still an important matter for dozens of producers of this $3.25 billion-per-year product.

At the moment, sulfuric acid's steady expansion of recent years has slowed down because of trouble in its dominant market, phosphate fertilizer. Sulfuric is feeling some of the same price and profits pinch that has hit downstream.

Producers saw their hopes for a slight improvement in demand in 1981 dashed in the second half of the year. Now they are hoping for improvement again beginning in the second quarter of 1982. But there is no actual relief in sight.

Instead of a potential production increase of 1.5% in 1981, output apparently dropped 4 to 5%, or about 2 million tons (as 100% H_2SO_4) to about 42.5 million tons. Of course, that still leaves sulfuric well ahead of all other U.S. chemicals in volume.

In 1982, producers hope to compensate for a slow first quarter with a spurt in production in the second quarter and a high enough second half to hold on to the gain. If such a forecast proves accurate, production might rise a million tons in 1982 to around 43.5 million tons. Even so, output still would be below the 44.5 million tons in 1980, the last of the big fertilizer demand years.

Given two years of fairly flat volume, sulfuric has no problem in sufficient plant capacity and probably won't for several years. Current nameplate capacity is close to 60 million tons a year. It didn't exceed this figure in 1981 as expected because construction was delayed wherever possible, just as with capacity expansions in derivative phosphoric acid. Aside from such concurrent expansion with phosphoric acid, no other new sulfuric acid capacity is planned.

By-product sulfuric acid capacity from copper and other smelters also will expand little this year or next. Enough smelter acid capacity appears to be available to meet minuscule new industrial needs and possible demand increases in ore processing such as uranium.

The other main variable in sulfuric supply and demand, foreign trade, is small and quite volatile. Trade depends on nonchemical demand factors such as labor disruptions in the U.S. and Canadian smelting industries. Smelter shutdowns during strikes can draw in some foreign acid to both countries.

Behind the delay in new sulfuric acid capacity and the large overcapacity in sulfuric plants not connected to phosphoric acid are technical and regulatory forces as well as the poor market. Sulfuric plants, in contrast to phosphoric units, deteriorate rapidly if shut down. Hence, sulfuric plants still run at low levels even in times of scant demand. This pushes up production artificially. Then too, some sulfuric units at smelters must be oversized for a margin of safety to absorb all possible sulfur dioxide from the furnaces to prevent air pollution. These large sulfuric units can bloat sulfuric supply.

Sulfuric's odd capacity mix can cause a variety of strange market situations. Some can depress prices and profits.

The biggest problem occurs when phosphoric acid demand falls off and related high-priced sulfuric acid is offered to outside customers whose supply of low-priced smelter acid is disrupted. These customers, accustomed to cheap raw material, can bargain hard.

This is precisely what has happened in the second half of 1981 and so far in 1982 as derivative fertilizer production holds at a relatively low level. The diversion of acid to new customers has occurred even though sulfuric producers have throttled back their plants as much as they can, reduced inventories of acid and raw material sulfur, and minimized other operating costs.

The reduction in sulfuric operations has led to a small recovery in sulfur producers' own stocks after a long drawdown which boosted sulfur prices. As yet, sulfur prices have not come down. The probable reason is that competing production of sulfur in oil refining and natural gas processing has declined because of weak fuel markets. So the sulfur supply is not glutted.

Because more than 70% of sulfuric acid goes into fertilizer, the current slack in the fertilizer business has to hurt sulfuric. It will take an upturn in fertilizer to pull up sulfuric in 1982, and farmers in the U.S. and abroad are in no hurry yet for more supply.

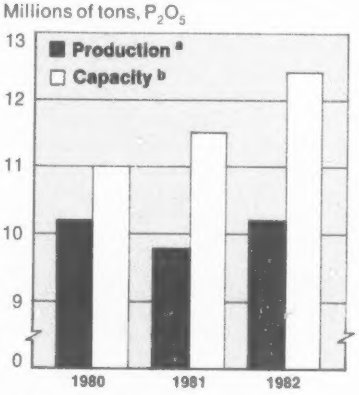
Key Chemicals

H_3PO_4

Phosphoric Acid

- ***Demand curbed***
- ***Capacity rise slowed***
- ***Prices shaved***

PRODUCTION/CAPACITY



[a] Both wet-process and furnace acid.
[b] First quarter.

HOW MADE

Reaction of phosphate rock with sulfuric acid; burning of elemental phosphorus and subsequent reaction with water

MAJOR DERIVATIVES

Ammonium phosphates 60%, triple superphosphate 20%

MAJOR END USES (U.S.)

Fertilizer 85%, detergent materials 5%, animal feed 5%

FOREIGN TRADE

Exports—may exceed 1 million tons as P_2O_5 in acid, imports—small, may reach 100,000 tons

PRICES

\$300 to \$425 per ton of P_2O_5 for fertilizer

COMMERCIAL VALUE

\$4 billion for production, 1982

The rip-roaring U.S. phosphoric acid business of the past several years has sputtered into the same doldrums as its dominant market, phosphate fertilizer. Phosphoric's exalted plant-use rates, prices, and profits all have come down to earth. There they will lie until farmers here and abroad pick them up again.

Since U.S. farmers are getting poorer by the month as crops set new records and prices tumble, exports are the leading hope for phosphoric acid. But phosphoric exports are flat or falling even though Occidental Petroleum's big shipments to the Soviet Union are going full blast.

U.S. phosphoric acid producers still see 1982 as a year of potential recovery. They hope to match 1980 production, following an unexpected decline of 4% in 1981 production to 9.8 million tons. But they will have 13% more plant capacity to use. This suggests that prices will be under more downward pressure during the year.

For 1982, the breakdown of phosphoric acid production, in terms of P_2O_5 (to accommodate the different acid concentrations and derivatives made without isolating the acid) could be about 9.5 million tons of "wet-process" acid and 700,000 tons of "furnace" acid. Just about all of the wet acid, produced from sulfuric acid and phosphate rock, will go into fertilizer or animal feed. Furnace acid, produced mainly from elemental phosphorus in electric furnaces, will go largely into detergents, food and beverages, dentifrices, and certain metal treatments.

Plant capacity for phosphoric acid is growing only in the wet-process area. Wet acid capacity will total nearly 11.4 million tons per year this quarter if some new units are completed. About 1 million tons of capacity exists for furnace acid, a figure that has been level or slightly down in recent years.

Further capacity additions in 1982 for wet acid are expected to be small, if anything. Earlier planned expansions are being delayed if at all possible because of the overcapacity situation.

The relatively large capacity for phosphoric acid guarantees a sharp drop in capacity use from super-tight 1980. That year, wet-process phosphoric plants ran at an estimated average rate of 95% of nameplate capacity. Although capacity for phosphoric acid is one of the most difficult in the chemical industry to pin down, most analysts agree that operations in 1979 and 1980 were so good that companies rushed into a round of plant additions. This expansion raised capacity almost 1 million tons in 1981.

Unfortunately, the immediate result was plant shutdowns. Industry analysts estimate that capacity shut down in 1981 was greater than the plant additions for varying periods. Shutdowns included some of the new capacity, which was run just long enough to check the work of construction contractors. Therefore, if 1981 production of wet-process acid totaled 9.1 million tons, the apparent average operating rate then fell to 87% of the 10.5 million tons of capacity available as the year opened. Capacity use then slipped during the year as additions were completed and now stands at about 82%.

This average doesn't look good for plants that can operate for extended periods at 110% of official capacity. But the picture isn't quite that bad. If 500,000 tons of the new 1981 capacity were available for operation, total capacity for 1981 would have been about 11 million tons. If 1 million tons were shut down for the year, then the operating rate for the rest would have been nearly 100%, just what the industry likes.

Currently, even more capacity may be down, perhaps 1.5 million tons. Phosphoric acid producers expect a slow first quarter because fertilizer dealers buying phosphoric derivatives know that farmers are in poor financial shape. Grain prices are down as farmers sell their inventories to meet debts and current cash needs.

Production of phosphoric acid likely will pick up during the second quarter, producers forecast, and hold up better than in 1981 as export sales improve for derivatives and for the acid itself. This consensus assumes that no U.S. government embargo appears on sales to the Soviets and that weather worldwide doesn't hamper agriculture to any significant extent.

But such improvement likely will not help phosphoric very much, and total value in 1982 may be no more than in 1981.

Europe's slump to continue in first-half 1982

West European chemical executives aren't sorry to see 1981 behind them. Admittedly, some sectors of the industry fared better than in 1980, but that's cold comfort considering that 1980 was generally a poor year.

For 1982, the expectation ("hope" probably is a more apt word) is that there will be a quickening in the pace of overall economic activity that will serve to pull chemicals' growth along with it. The general consensus, however, is that the first half of the year will remain fairly flat, and that any pickup won't make itself felt until the second half.

According to a position paper issued a few weeks ago by the European Council of Chemical Manufacturers' Federations (CEFIC), "The West European chemical industry will have to work out a new growth strategy. This will be focused on three main aspects—raw materials supply, efficiency of processes, and development of high-technology-intensive products."

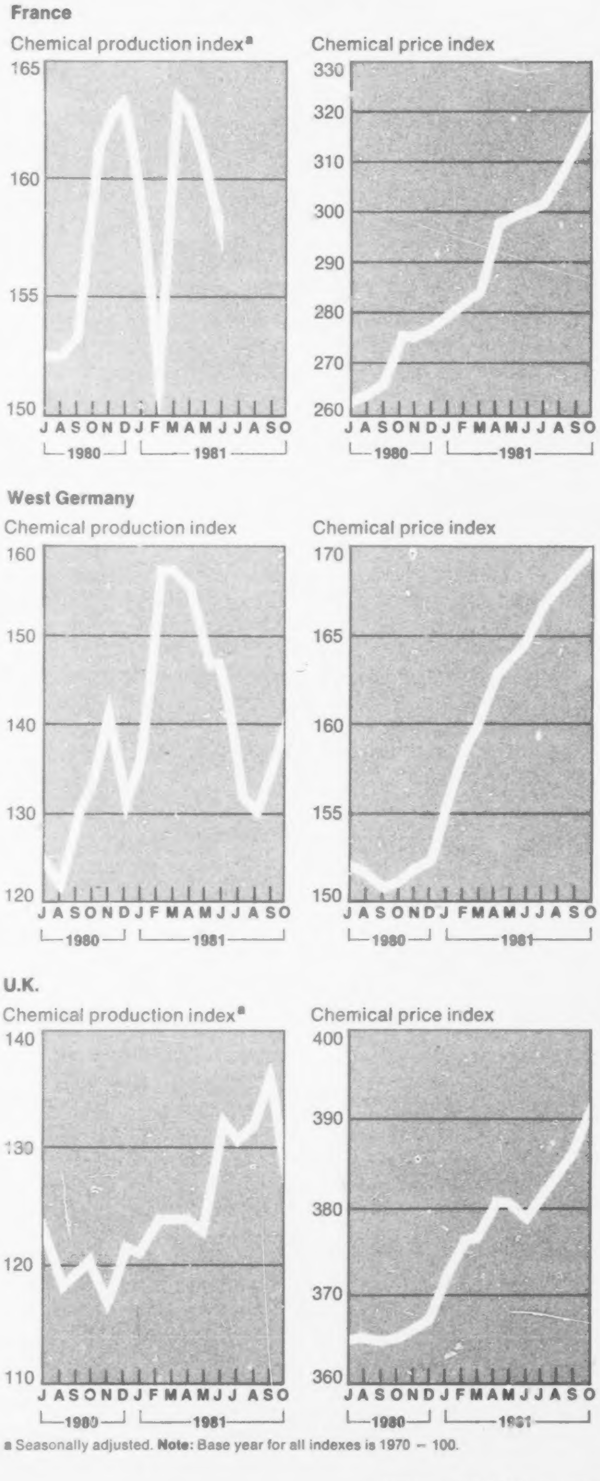
Western Europe isn't an economic "whole" in the same sense that Canada, for example, or the U.S. are. Development of the chemical industry in individual European countries, therefore, will be affected largely by a variety of influences specific to each country. The French nationalization program, for instance, which embraces the most important segments of the country's chemical industry, probably will come to final fruition this year. But its implementation will be delayed somewhat by a recent ruling of France's highest judicial body that several provisions of the nationalization law, approved by the country's National Assembly last month, are unconstitutional.

West Germany remains concerned about the continuing high cost of energy and raw materials, mainly owing to the fall in value of the Deutsche mark against the U.S. dollar. Karl Wamsler, in his outgoing speech as president of the Chemical Industries Association there, foresees that chemical companies' earnings in West Germany will be hurt again this year by rising costs and a weak economy as they were last year.

Although 1981 admittedly is history, statistical information still is coming in. France is the furthest behind in chemical production index data, with values currently available through last June. At 157 (1970 = 100), the index almost was unchanged from the January reading of 158. If the 1980 pattern of events is repeated, production last July and August will have slipped lower, with the probability of a slight upturn appearing in September, further strengthening in October. The average monthly reading for the first half of 1981 was 3.7% lower than the like 1980 level.

For both West Germany and the U.K., production index data are available through last October. In West Germany's case, the average monthly reading stood at 144.2 (1970 = 100), 1.8% ahead of that between January and October 1980. The U.K. didn't fare as well. Although the October 1981 reading of 131.1 (1970 = 100) was almost 9% up from the previous January's, the average during the year's first 10 months was almost 1% below the average for January through October 1980.

Dermot O'Sullivan, London


France

Chemical production index[a]

Chemical price index

West Germany

Chemical production index

Chemical price index

U.K.

Chemical production index[a]

Chemical price index

[a] Seasonally adjusted. **Note:** Base year for all indexes is 1970 = 100.

Chemical &
Engineering **NEWS**

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C_1 chemistry spurs cluster
catalyst development by industry
Page 13

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Hydrometallurgy

Refining metals with
solutions rather than heat
Page 46

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Chemical & Engineering NEWS

Cover: Salt storage bins (center) and first-stage leaching reactor (right) are part of plant at Sierrita, Ariz., the first to use Duval's CLEAR hydrometallurgical process for recovering copper from sulfide ore concentrate

4 Letters
5 Editor's Page

Concentrates

22 Business
25 Government
30 Science/Technology

The Departments

45 New Products
62 ACS News
78 Newscripts

News of the Week

- ***Fourth-quarter 1981 earnings are down*** *at most chemical companies, despite earlier favorable predictions; Dow Chemical among hardest hit.* ***Page 6***
- ***Producers of lead additives*** *for gasoline ask Federal Trade Commission to reverse ruling on unfair practices.* ***Page 7***
- ***Hazardous waste task force*** *set up by EPA to seek cooperation of private parties in cleanup of dump sites covered under the superfund law.* ***Page 7***
- ***California OSHA lists 794 chemicals*** *and classes of chemicals being considered for regulation.* ***Page 8***
- ***Chevron ending its fibers operations;*** *will shut down Maryland plant and plans to sell another in Tennesee.* ***Page 8***
- ***Nuclear primer*** *published by League of Women Voters discusses reactors, risk assessment, safety, and economics.* ***Page 8***

News Focus

- ***Research on cluster catalysts,*** *typically metal aggregates surrounded by stabilized ligands, has picked up in response to growing interest in C_1 chemistry.* ***Page 13***

Business

- ***Aramid fibers output continues to grow*** *at strong pace, unlike rest of fibers industry; 20% annual growth rate of Du Pont's Kevlar attracts challenge from Enka.* ***Page 23***

Government

- ***Chlorinated biphenyls dispute****—whether MCBs are the same as PCBs and subject to the same regulation, as claimed by EPA, or whether they are different, as contended by Dow—still hasn't been resolved.* ***Page 26***
- ***OSHA appears to have changed its thinking*** *on importance of costs in complying with regulations and on best means of controlling worker exposure to substances.* ***Page 27***

Science

- ***Saturn and its system of rings and moons*** *are yielding to more analysis of data from Voyager 1 and 2; rings may have come from breakup of early moons.* ***Page 37***
- ***Nuclear power's link to spread of nuclear weapons*** *debated at American Physical Society meeting; experts disagree as to nature and even existence of tie.* ***Page 39***

Special Report

Hydrometallurgy, *recovering metals by use of aqueous solutions at relatively low temperature, increasingly is competing with dry high-temperature pyrometallurgical methods for processing ores.* ***Page 46***

Books

- ***"Reflections on Science and the Media,"*** *by June Goodfield, AAAS, focuses on journalists as the crucial link between scientists and the public.* ***Page 59***

MOST CHEMICAL FIRMS' EARNINGS DOWN

Many U.S. chemical companies will remember 1981's fourth quarter as a most unpleasant surprise.

At the beginning of the year, predictions had called for a rosy fourth quarter; the chemical industry and, indeed, the entire economy would have turned around from the 1980 recession and would be well into recovery. The construction industry and the automobile industry, big users of chemicals, both would have revived, interest rates would have fallen, and inflation would have abated. U.S. demand, if not worldwide demand, would have risen.

As the fourth quarter came and passed, it became painfully obvious that those predictions were far from the mark. And for the U.S. chemical industry, the miserable economy spelled plummeting earnings, sometimes deficits for the quarter. Now, almost midway into the new year's first quarter, the economy not only has not turned around but has fallen again into recession—this one possibly worse and more long-lived than in 1980. Autos and construction are still in a mess. Interest rates are still high, and a number of banks raised their prime rates again last week. Demand for chemicals remains very low, and chemical industry forecasters don't yet see a bottom to the slump. The only good sign is that inflation has finally eased.

For the 22 companies that have reported their fourth-quarter earnings thus far, 13 have posted declines in net income from continuing operations compared to the previous year's fourth quarter, and two—Akzona and Pennwalt—have had deficits. In addition, 11 of the companies reported sales declines from the 1980 period.

One of the worst earnings declines was at Dow Chemical, whose profits dropped 73% to $66.5 million. However, its sales increased 8% to $2.99 billion. As a result, the company's profit margin dropped to 2.2% in fourth-quarter 1981 from 8.7% in fourth-quarter 1980. One of the big problems for Dow was its large-volume plastics. Chairman Paul F. Oreffice says, "Our earnings in the fourth quarter suffered from the combined effect of reduced operating rates and lower prices. This was particularly true among our high-volume plastics such as polyethylene and polystyrene."

The largest sales decline posted so far, 17%, not surprisingly was at International Minerals & Chemical, where slumping demand for fertilizer products pulled revenues down. IMC's sales were about $409 million in the quarter. Its earnings of $28 million were 33% below those a year

Earnings drop in fourth quarter at most chemical companies

	Fourth-quarter 1981						Full-year 1981					
			Change from 1980		Profit margin[b]				Change from 1980		Profit margin[b]	
	Sales	Earnings[a]	Sales	Earnings	1981	1980	Sales	Earnings[a]	Sales	Earnings	1981	1980
Air Products[c]	$ 373.6	$ 34.6	2%	7%	9.3%	8.8%	$ 1,577.2	$ 128.3	7%	10%	8.1%	7.9%
Akzona	276.5	−2.2	−1	def	def	0.7	1,137.6	11.6	13	138	1.0	0.5
Allied Corp.[d]	1,696.0	92.0	17	−4	5.4	6.6	6,407.0	343.0	16	13	5.4	5.5
American Cyanamid	927.1	48.4	1	nc	5.2	5.3	3,649.1	197.1	6	24	5.4	4.6
Diamond Shamrock	872.5	59.7	3	9	6.8	6.4	3,376.2	230.2	7	8	6.8	6.8
Dow Chemical	2,985.0	66.5	8	−73	2.2	8.7	11,872.7	563.5	12	−30	4.7	7.6
Ethyl Corp.	430.3	23.9	nc	−3	5.6	5.7	1,757.2	90.9	1	1	5.2	5.2
First Mississippi	95.6	6.2	−3	−26	6.5	8.5	350.1	23.7	19	−7	6.8	8.7
Freeport-McMoRan	199.8	30.6	5	−21	15.3	20.2	835.4	159.0	19	−2	19.0	23.1
H. B. Fuller	82.4	3.2	5	8	3.9	3.8	328.7	13.6	11	53	4.1	3.0
W. R. Grace	1,759.3	81.7	3	20	4.6	4.0	6,520.8	361.3	6	26	5.5	4.7
Hercules[e]	649.0	27.4	3	−12	4.2	4.9	2,718.0	147.4	9	29	5.4	4.6
International Minerals[f]	409.1	28.0	−17	−33	6.8	8.4	1,940.8	144.7	nc	−17	7.5	9.0
Monsanto[g]	1,558.2	51.8	−6	31	3.3	2.4	6,947.6	377.5	6	47	5.4	3.9
Nalco Chemical	177.6	21.3	9	6	12.0	12.4	666.6	81.2	8	12	12.2	11.7
Olin[h]	445.2	13.8	−5	10	3.1	2.7	2,001.3	92.8	7	26	4.6	4.0
Pennwalt	250.5	−2.7	−5	def	def	4.1	1,056.1	36.7	1	−7	3.5	3.8
PPG Industries	803.8	39.1	−5	−42	4.9	8.0	3,400	211.2	6	1	6.2	6.5
Rohm & Haas[i]	412.5	13.9	−1	−18	3.4	4.1	1,884.7	96.8	9	3	5.1	5.4
S[illegible]ffer Chemical[j]	376.5	24.7	−12	−10	6.6	6.4	1,726.2	149.9	2	24	6.7	7.2
[illegible] Carbide	2,430.0	139.8	−9	−6	6.0	5.6	10,170.0	649.0	2	−4	6.4	6.7
Witco Chemical	306.7	11.2	−2	1	3.7	3.3	1,291.9	38.6	10	6	3.0	3.5

a After-tax income from continuing operations, excluding nonrecurring and extraordinary items. b After-tax income as a percentage of sales. c Excludes $61.9 million nonrecurring gain in fourth-quarter 1981. d Excludes $33 million nonrecurring gain in fourth-quarter 1981 and $5 million gain for full-year 1981. e Excludes nonrecurring loss of $9.4 million in fourth-quarter 1981. f Excludes nonrecurring gain of $41.3 million in fourth-quarter 1981. g Excludes $67.7 million nonrecurring gain for 1981. h Excludes nonrecurring charge of $40 million for fourth-quarter 1980. i Excludes nonrecurring charge of $3.7 million in 1981. j Excludes nonrecurring gain of $14.9 million for fourth-quarter 1980. def = deficit. nc = no change.

before. IMC chairman Richard A. Lenon says that "The decline in operating earnings is concentrated in the fertilizer business, with poor markets in the U.S. and abroad. Farmers are being squeezed by inflation, cheap food prices, restraints on access to foreign exchange, and, in some areas, adverse weather. Problems on the farm hurt all agribusiness, including. . .fertilizers."

The fibers business, earlier improving, also took its lumps in the fourth quarter. Akzona showed a loss of $2.2 million compared to a profit of $2.0 million in the same period of 1980. Its sales dropped 1% to about $277 million. Claude Ramsey, Akzona's chairman and president, says that the company "showed a modest earnings recovery for the full year, but recession had a dampening effect on several business areas, particularly in the fourth quarter, when large numbers of customers in various industries shut down plants for one or more weeks to avoid excessive inventory accumulations."

Ramsey is more bullish on 1982, however. He says, "All the operating companies were profitable in 1981, and we expect 1982 to be a year of moderate growth as improving business conditions should lead to gains in most sectors."

Foreign business also hurt many companies. One was PPG Industries, whose earnings fell 42% in the fourth quarter to $39.1 million. Sales for the quarter totaled almost $804 million, a 5% drop from fourth-quarter 1980. PPG chairman L. Stanton Williams says that "Results were affected by weak economies in Canada and Europe—our chief foreign markets—as well as by the strength of the dollar, which reduced exports and resulted in lower foreign earnings after conversion to U.S. currency."

There were a few companies whose sales declined in the fourth quarter while their earnings increased. For example, Olin's sales dropped 5% to a little more than $445 million, but its earnings rose 10% to $13.8 million. Olin chairman John M. Henske says: "As order entry slowed during the fourth quarter for most products, our program of upgrading our plants paid off handsomely, since we were able to operate many of our units more efficiently at lower operating rates than we have been able to do historically. Also contributing to the increase in net profits in the quarter was lower interest expense, as Olin ended the year with substantially reduced short-term debt." ☐

Lead additives makers appeal marketing curbs

The four U.S. producers of lead additives for gasoline took their case to the Federal Trade Commission last week, hoping to get the commission to reverse an earlier ruling that the companies have engaged in unfair practices to keep the price of their products high.

An FTC administrative law judge found last summer that although the four companies—Du Pont, Ethyl Corp., PPG Industries, and Nalco Chemical—did not conspire to fix prices, the marketing practices they used reduced uncertainty about price changes and resulted in lessened competition. In the period from 1974 to 1979, when demand for the alkyl lead antiknock compounds fell by some 70%, the companies raised their prices for the compounds 24 times. These increases were always identical in amount and usually took effect on the same day.

To remedy what he considered the noncompetitiveness of this market, judge Ernest G. Barnes ordered the companies to alter their marketing practices in four ways. The companies no longer can announce price changes ahead of the date they become effective, announce price changes to anyone but customers until 30 days after the increases have taken effect, calculate their prices on a "uniform delivered basis" that does not take into account differences in cost of shipping products to different locations, or put clauses into contracts that guarantee customers that they are receiving the product at the lowest price.

The additives producers argue that the things they are forbidden to do are ordinary business practices and that FTC is exceeding its authority by forbidding otherwise legal practices without showing that they were used as part of an agreement among the companies to keep prices high.

The commission's review of the arguments is expected to take several months. Even then the matter may not be settled, for a Du Pont spokesman already says that should the decision go against the company, Du Pont will appeal to federal court. ☐

EPA sets up task force for dump-site cleanup

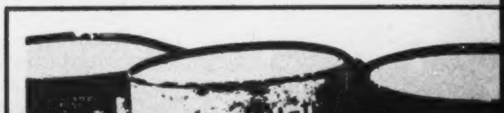
President Reagan's volunteerism program has invaded the realm of hazardous waste cleanup. Last week Environmental Protection Agency Administrator Anne M. Gorsuch announced that private parties responsible for the presence of hazardous wastes at sites covered under the superfund law would be given the chance to cooperate in the management of financing of the cleanup effort.

To prod this "private sector initiative," EPA has set up a special task force directed by the agency's enforcement counsel William A. Sullivan Jr. Sullivan says the task force "will notify parties of their potential liability for cleanup and pave the way for enforcement action to compel cleanup" if responsible parties fail to cooperate.

Contacted parties will be given 90 days to initiate voluntary action. If they do not cooperate, EPA will issue administrative orders requiring a cleanup, and then collect damages equal to three times the government's cost of cleanup.

The initial focus of this program will be the 115 sites EPA placed on a so-called "interim priority list" last October. The agency estimates that more than 1500 parties ultimately may be contacted by the task force. Parties include commercial waste haulers, firms that produced the wastes, and present or former owners and operators of the sites.

To date, 20 of the 115 sites are subjects of lawsuits. Of the remaining 95 sites, 122 individuals or firms associated with 16 sites have been notified that the site is marked for cleanup under the superfund program. And since May 1981, Gorsuch has approved more than $29 million to clean up 30 sites. ☐



FINAL PROGRAM
ACS spring meeting, Las Vegas
Page 38

Chemical & Engineering NEWS

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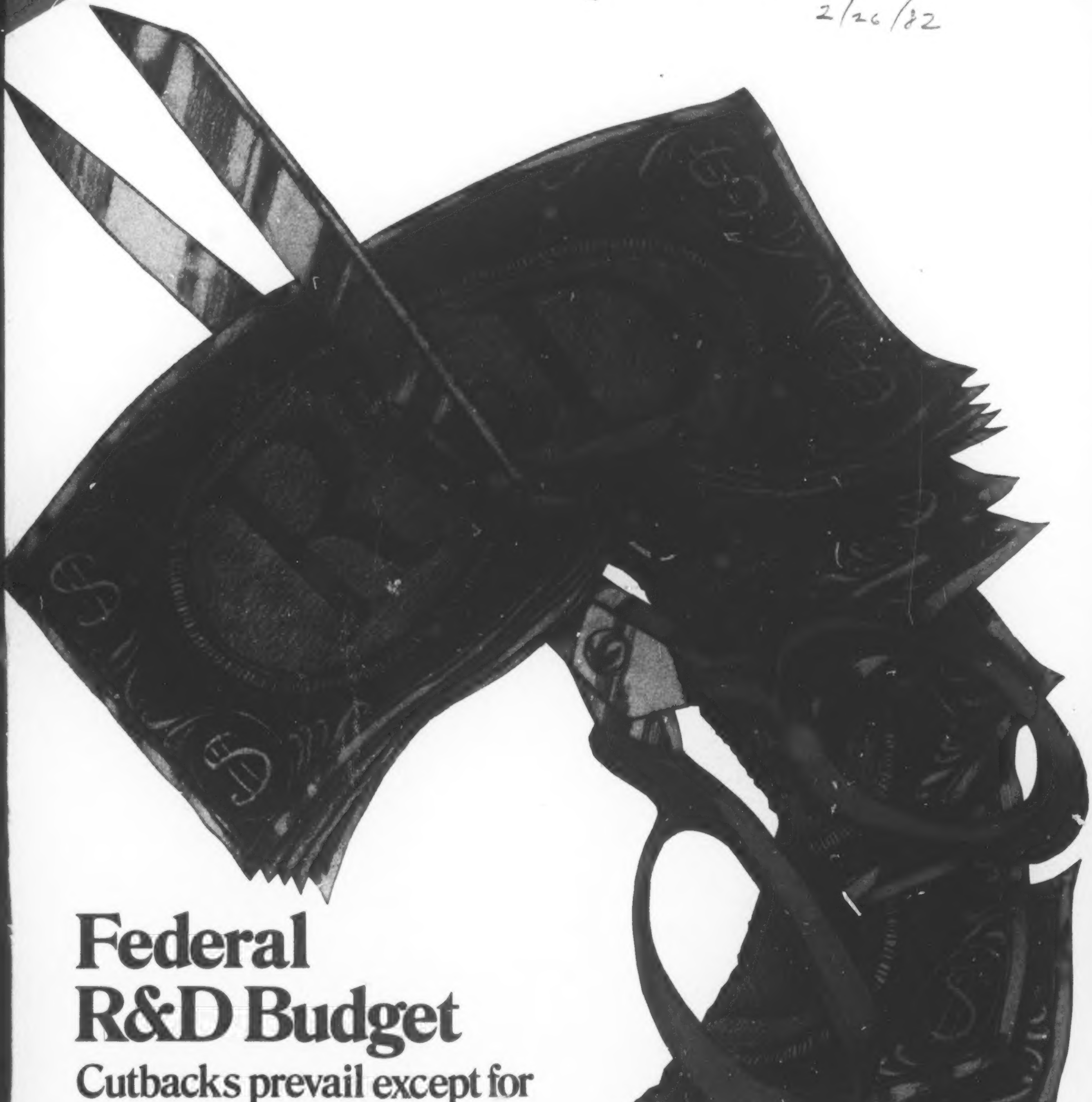

Federal R&D Budget

Cutbacks prevail except for defense Page 9

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Chemical & Engineering NEWS

4 Letters
5 Editor's Page

Concentrates
15 Business
24 Government
26 Science/Technology

The Departments
129 Meetings
130 Newscripts

News of the Week

- ***New series of engineering plastics*** *based on polyetherimide resin chemistry has been introduced by General Electric.* ***Page 6***
- ***Superfund cleanup of hazardous waste sites*** *will be managed by the Army Corps of Engineers under agreement with EPA.* ***Page 6***
- ***DNA committee has retreated*** *from its earlier position, now recommends adopting much of the substance of NIH safety guidelines for doing DNA research.* ***Page 7***
- ***Fertilizer is in for a tough year*** *with commodity prices depressed and farmers' real income down sharply.* ***Page 7***
- ***Production of stable isotopes*** *of many elements needed for research, medicine, and industry is falling short.* ***Page 8***
- ***One of the last barriers to renewed U.S. chemical arms output*** *has been broken down with a letter to the House from Reagan certifying need for such arms.* ***Page 8***

News Focus

- ***Federal funding for R&D*** *in fiscal 1983 would be up about 10% overall in Administration's budget request, but most of that increase would go to Defense Department.* ***Page 9***

Business

- ***Unexpected new recession*** *hit the U.S. chemical industry in the fourth quarter, dealing earnings a blow that likely will be felt until mid-year 1982.* ***Page 16***

Science

- ***Triggering of immune system*** *by clustering of cell surface receptors proposed by Johns Hopkins University researchers.* ***Page 27***

Perkin Medal

- ***Herbert C. Brown*** *awarded Perkin Medal in recognition of outstanding contributions in applied chemistry.* ***Page 29***

Education

- ***Proportion of recent Ph.D.s*** *on science faculties in Ph.D.-granting departments continues to decline.* ***Page 32***

Technology

- ***Gasification tests using moist peat*** *have been completed successfully in IGT's Chicago pilot plant.* ***Page 33***
- ***Gene has been cloned*** *for rennin, an enzyme used in cheesemaking.* ***Page 34***

ACS News

- ***Advisory board members*** *for society's publications named.* ***Page 35***

Final Program

- ***Program for ACS National Meeting*** *in Las Vegas includes technical sessions, chemical exposition, social events.* ***Page 38*** up, and help maintain consistency with EPA's program requirements.

Funding for the corps' part of the program will come from the $1.6 billion superfund, which is budgeted for $190 million in fiscal 1982 and $230 million for 1983. In addition to supporting EPA and the corps in this work, the money also will be used to fund the contractors for the remedial cleanup. EPA also will manage liaison with the states and other groups regarding cleanup and handle all preliminary measures at hazardous sites, such as early investigations and feasibility studies.

In addition, the corps will not be required to manage any remedial plan proposed by EPA that the corps does not think feasible. The agreement between the two agencies is for two years. The superfund law, passed in 1980, is to run through 1985, but Gorsuch says that cleanup action at the hazardous sites is expected to last beyond that time. ☐

DNA group backtracks, wants some guidelines

The Recombinant DNA Advisory Committee (RAC) now recommends adopting proposals that simplify but do not eliminate much of the substance of the National Institutes of Health safety guidelines for doing recombinant DNA research.

In so doing, the committee backtracked from the position it held last fall when it recommended that the guidelines become a code of voluntary practices, that the limited sanctions against researchers who fail to comply be dropped, and that all requirements for prior approval of experimental protocols be eliminated (C&EN, Sept. 21, 1981, page 6). RAC's retreat led to adopting a minority set of proposals, put together by former RAC member and NIH senior investigator Susan K. Gottesman. The rejected set of proposals had been presented by RAC member David Baltimore, a biologist at Massachusetts Institute of Technology and also the head of the new MIT-affiliated Whitehead Institute for Biomedical Research.

Both sets of proposals were published in the *Federal Register* last December (C&EN, Dec. 21, 1981, page 25). Thus, the newly approved Gottesman proposal can take effect whenever approved by either Richard M. Krause of NIH, who currently holds that authority, or a new NIH director, still to be appointed.

The Gottesman proposals leave certain features of the current NIH guidelines intact. During the February meeting of RAC, a change of heart surfaced as to the value of preserving some of those provisions and slowing down an earlier move to declare gene-splicing research finally safe enough to be left to self-governance.

The public response to the two sets of proposals, as represented in dozens of letters sent to NIH, has been mixed. Though many letters espouse doing away with much in the guidelines and adopting Baltimore's proposals, many of the letters recommend a more cautious, middle-of-the-road stance.

This same mix is reflected within RAC itself and helped to lead to the backtracking. Baltimore implored the committee to a bolder move: "RAC's function is to lead the world, not follow," he says. "We must make the assessment of risk and tell the city of Cambridge and of Waltham and tell California that it's our opinion that regulations beyond our recommendations are not necessary. That this is national policy."

This suggestion, though debated, was not followed by RAC, which elected to err toward the side of caution instead.

An important vehicle for ensuring that caution is exercised, for example, is the institutional biosafety committees (ICBs) that Gottesman's proposal leaves intact. There still are questions regarding certain experiments, Gottesman noted during the RAC meeting. "Someone else should be overseeing them. It makes sense to say 'we really mean this.' Let's say that explicitly."

Leaving the NIH guidelines in place also might help to prevent the fragmentary, community-by-community introduction of regulations that some observers fear may occur if the federal presence disappears. Besides, Gottesman's proposals are a long way from the cumbersome guidelines of a few years ago. "My proposal does nothing to bring back all the experiments that are now exempted," she points out. "Having mandatory guidelines is not synonymous with bureaucracy. The basic structure is simple enough to last a long time." ☐

C&EN staff photo

Gottesman: guidelines not bureaucracy

Farmers' slump hurts fertilizer sales

The 1982 fertilizer year? "It's going to be a tough row to hoe," says Edwin M. Wheeler, president of the Fertilizer Institute. At the institute's annual meeting in Chicago, Wheeler noted that although farmers' costs were up, commodity prices were depressed and farmers' real income was down dramatically. "We do well when our farmers prosper, but we suffer when they suffer," he observes.

For the full fertilizer year (July 1981 through June 1982), Wheeler predicts that U.S. nitrogen consumption will drop 2 to 5%, compared to the preceding year. Phosphate consumption will be down 10 to 15%, he says, and potash consumption will be off 10 to 12%.

Latest institute and government figures for the second half of 1981 give weight to Wheeler's gloomy predictions. U.S. fertilizer consumption, in terms of "domestic disappearance," declined 9% from the record year-earlier period. Fertilizer exports decreased 28%. Inventories of all products increased 32%, despite a 7% production cutback during the period.

Nitrogen products were least affected, with production steady, domestic disappearance off 3%, and inventories up 28%. Exports of all nitrogen products were down, however, and solid urea exports were off a sharp 35%.

Phosphate rock production decreased 7% during the six-month period. At the same time, wet process phosphoric acid production decreased 23%, leaving year-end rock inventories of nearly 20 million tons, 49%

Fertilizer consumption drops 9%

Index change, July–December 1981 vs. 1980	Production	Ending Inventory	Domestic Disappearance
Nitrogen products	0%	28%	−3%
Phosphate rock	−7	49	−23
Processed phosphates[a]	−26	37	−27
Potash products	−2	112	−11
Mixtures	−27	12	−28
All products[a]	−7	32	−9

[a] Excludes some product types. **Source:** Fertilizer Institute

higher than a year earlier. For processed phosphates as a group, production declined 26% and consumption dropped 27%, while year-end inventories grew 37%. One bright spot was a 44% increase in phosphoric acid exports during the period. For other phosphates, however, exports decreased from 1980 levels.

U.S. production of potash products decreased 2% during the July-through-December period; potash consumption declined 11%; and year-end inventories more than doubled, to 112% of 1980 levels. Potash exports were down 39% and imports, mostly from Canada, were down 11%.

Domestic disappearance of NPK solid mixtures (the best indicator of fertilizer movement to farms, the institute notes) decreased 28% during the six-month period. Production of solid mixtures decreased 27%, while ending inventories rose 12%. ☐

U.S. faces stable isotope shortage

The U.S. is falling short in producing separated stable isotopes of many elements in amounts needed for research, medicine, and industry. Highly enriched stable isotopes themselves are used in studies of the nucleus, as reference standards for dating and atomic weight determinations, and for analytical methods in which such properties as nuclear spin are important. Stable isotopes also are precursors for production of radioactive isotopes by neutron irradiation or charged particle bombardment for radiochemical research, medical diagnosis and treatment, and industrial use.

This shortage problem came under scrutiny at a workshop for suppliers and customers held by the National Research Council's Committee on Chemical Sciences and its Subcommittee on Nuclear and Radiochemistry and supported by the Department of Energy and the National Institutes of Health. NRC plans to issue a report on it in April.

Production shortfalls of concern are occurring at the electromagnetic isotope separating facility at Oak Ridge National Laboratory in Tennessee. ORNL separates isotopes of most stable elements from magnesium to bismuth in banks of modified cyclotrons. Of 225 stable isotopes ORNL can produce, 60 are now out of stock, with waiting times of a few years before they can be replenished. Lagging production rates will result in increased inventory gaps as scientists continue to buy.

One problem is that ORNL operates only two of its four banks of separators for stable isotopes on an annual budget of $2.5 million. Each bank can separate about 0.1 gram atom of one element per 24-hour day, running five days per week. Eugene Newman, head of ORNL's isotopes section, told workshop attendees that he could serve present needs and begin rebuilding inventories, if he could run all four separator banks.

A second problem is the different needs of ORNL's research and industrial customers. Scientists tend to need small amounts of every isotope of all the elements for specific projects. Companies that supply radiopharmaceuticals need large amounts of a few isotopes. Newman estimates that 80% of his unit's activity in the past year went to supply large amounts of isotopes of only four elements. ☐

President certifies chemical arms need

President Reagan now has knocked down one of the few remaining barriers to renewed U.S. production of chemical warfare weapons. Last week, in a letter to House Speaker Thomas P. O'Neill Jr. (D.-Mass.), Reagan certified "that the production of lethal binary chemical munitions is essential to the national interest." That letter ends a nearly 13-year moratorium on chemical arms manufacture.

In a supporting document, the Defense Department says that "the overall military balance between the U.S. and the Soviets" does not allow the U.S. to call on its other weapons to deter chemical warfare. According to Pentagon reasoning, a beefed-up chemical retaliatory capability will offer deterrence and an incentive to the Soviets to negotiate a comprehensive and verifiable ban on such weapons.

Current chemical stocks are an ineffective deterrent, the Pentagon claims. Most of the stockpile is stored in bulk containers and the remainder is in ammunition for weapons that are obsolete or soon will be retired. Also no chemical weapon in stock has a long enough range to penetrate "the rear echelons of attacking forces," according to the Pentagon.

To correct these defects, the Pentagon plans to manufacture so-called binary 155 mm artillery shells and Bigeye bombs. In these weapons, two nontoxic chemicals would mix in flight to form lethal nerve gases. In addition to these short-range weapons, the Army also is studying the feasibility of producing longer range delivery systems, including the ground launched cruise missile, and more potent chemical agents.

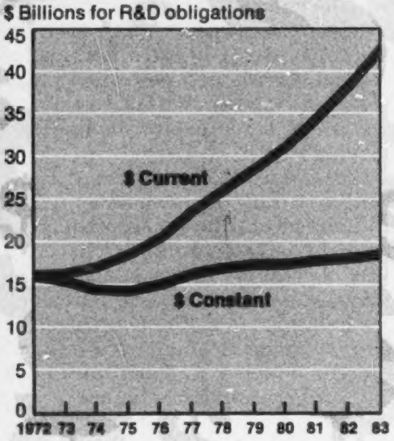
The Pentagon claims that binary weapons offer "considerable safety, security, and logistical advantages" over present unitary weapons. Yet no accident has ever been reported in the manufacture, storage, transportation, or disposal of the unitary weapons. And Harvard University biochemist Matthew Meselson, a chemical arms expert, recently told a scientific meeting that binary arms would be difficult to assemble under tense battlefield conditions.

Because of the issue's sensitivity, the Pentagon says no decision has been made on overseas deployment of these new weapons. Such a decision would be made with "full consultation" of the nations involved.

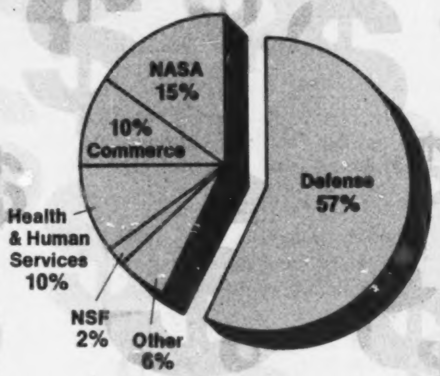
The Administration has requested fiscal 1983 funds totalling $705 million to support its expanded chemical program. More than 70%, or $508 million of that, is to improve all aspects of chemical defense. Nearly 20%, including $30 million for the procurement of binary arms, is slated for the retaliatory program. The U.S. still maintains a no-first-use, retaliation-in-kind strategy, and the Pentagon says it has no plan to match the Soviets in kind or quantity of agent or munition. But it will build an offensive program that can "deny a significant military advantage to any initiator of chemical warfare."

Congress still has the final say in this matter, however. It could block renewed chemical arms production by deleting the requested funds from the budget. ☐

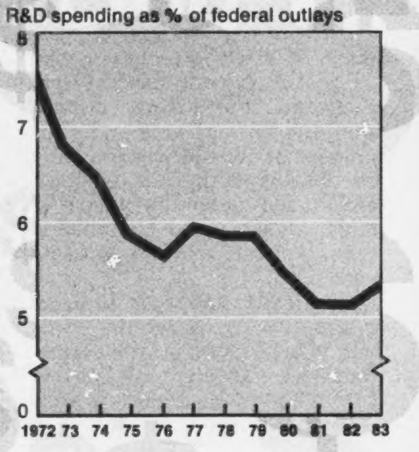
R&D funds to rise 4% in constant dollars



Department of Defense gets well over 50% of R&D budget



R&D funding accounts for 5% of federal outlays



Federal R&D holds its own in fiscal '83 budget

Overall research funding would increase about 10% under Administration's budget requests, but more than 90% of that increase is slated for the Department of Defense, and most agencies barely are keeping up with inflation

Janice R. Long and David J. Hanson
C&EN, Washington

President Reagan officially presented his first complete budget proposal to Congress last Monday. And, despite predictions of doom, research as a whole would not fare too badly. In a budget that would rise only a little more than 4% to $757.6 billion, but with a $91.5 billion deficit, outlays for federal R&D funding would be up just less than 10% to $41.1 billion. Obligations for R&D would be up almost 11% to a little less than $43 billion.

But—and there are some important buts—94% of that $4.2 billion increase in obligations is slated for the Department of Defense, whose R&D budget would account for 57% of the total federal R&D budget in fiscal 1983, 10% more than it did in fiscal 1981. Whether the R&D budgets of many other federal agencies will be up, even, or down in constant-dollar terms depends in large part on how accurate is the Administration's prediction of a mere 6.5% inflation rate in 1983. And, most important, in the proposed 1983 budget R&D funding requests for a few agencies are actually below not only fiscal 1982 but fiscal 1981 funding levels as well.

One bright spot is that basic research would be exempted from the budget scissors. Total obligations would be up 8.8%, or $473 million, to $5.8 billion. Outlays, however, would be up only 4.4%, or $238 million, to $5.5 billion. The largest increases for basic research are slated for the National Aeronautics & Space Administration, up 18%, and for DOD, up 16%. Support for basic research by the Environmental Protection Agency and the Department of Interior would be down 33% and 7%, respectively. Those are the only agencies slated for a decrease in basic research.

The Office of Management & Budget, in the special analysis of the federal R&D budget that it prepares, points out that "about one half of the total federal obligations for basic research are made to support researchers in universities and colleges." But this year OMB has not prepared a separate breakout, by agency, of federal R&D funds slated for colleges and universities as it has in the past. The reason, as one OMB official puts it, is that "historically the breakout has not been too accurate" and there have been, and are, questions about the credibility of the data.

However, OMB, as usual, has broken out funding for R&D facilities and in that category the news is bad. Obligations would be down 17%, or $265 million, to $1.3 billion, and outlays would be down almost 30%, or $503 million, to $1.2 billion.

A breakdown of the federal R&D budget by agency clearly shows that with its huge 21.3% increase in research, development, testing, and evaluation funding for fiscal 1983, the Department of Defense overshadows all the rest of federal R&D spending combined. Most of the

$24.3 billion requested, however, would be spent on development and testing of huge weapons systems. Only $781 million, up from $673 million in the revised 1982 budget, would be spent on basic research.

Most of the funding for development of existing technology would go to strategic and tactical weapons programs. For instance, increases would go toward accelerated development of alternatives for MX missile basing, either in deep underground silos or continuous-patrol aircraft; an advanced technology B1-type bomber; and an antisatellite system.

Tactically, under the budget proposal the Army would continue major efforts to improve the performance and capabilities of the M-1 tank, chemical weapons defense equipment, and chemical weapons. The Air Force would move on development of improved night and foul weather navigation systems and the AMRAAM advanced medium range air-to-air missile. The Navy would develop a lightweight antisubmarine torpedo, a new destroyer, and a vertical launch system for missiles.

For its technology base, DOD continues to develop promising new technologies. Current work on high-speed integrated circuits and guided missiles will continue. Increased emphasis would be placed on improved information processing, better materials, and improving sensing devices. Other programs listed by DOD for fiscal 1983 include a lot of electronic technology, such as devices that continue to work after some components have failed, electronics that are resistant to radiation, advanced computer languages, and high-power lasers.

The defense activities of the Department of Commerce also are slated for a sizable increase of 15%, or $657 million, to $5.1 billion in fiscal 1983. (That's right—Commerce. For the purpose of preparing this budget OMB decided that the Department of Energy no longer existed, even though legislation for its dismantlement has not been sent to, let alone approved by, Congress. But whether DOE stays DOE or its programs go to Commerce, the numbers are the same.)

The large increase for defense activities comes hard on the heels of a 27% rise in fiscal 1982. Weapons activities are slated for a 16% increase to $3.2 billion, with $1.1 billion, an increase of 15%, earmarked for R&D and testing. Funding for materials production would be up 14% to $1.0 billion, defense waste management up 6% to about $408 million, naval reactors development up 17% to about $392 million, verification and control technology up 7% to $52.5 million, nuclear materials security and safeguards up 9% to $46.7 million, and security investigations up 26% to $26 million.

Glossary of budget terms

Deferral. Any executive branch action or inaction that delays the availability of budget authority for obligations. Deferrals may not extend beyond the end of the fiscal year and may be overturned at any time by either branch of Congress.

Fiscal year. Year running from Oct. 1 to Sept. 30. The fiscal year is designated by the calendar year in which it ends.

Commitments made by federal agencies to pay out money for products, services, or other purposes, as distinct from the actual payments.

Outlays. Payments for obligations incurred under budget authority, generally made by issuance of checks by Treasury. Outlays during any fiscal year may be payments of obligations incurred in prior fiscal years or in the same fiscal year.

Rescission. Enacted legislation canceling budget authority previously granted by Congress. Rescissions proposed by the President must be approved by Congress within 45 days to become effective.

With two exceptions, funding for the other research programs Commerce may or may not inherit from DOE can best be described as disaster areas. One of the exceptions is general science and research, funding for which would be up 11% to $601 million. Within that category, funding for nuclear physics would be up 16% to almost $133 million and high-energy physics would be up 11% to $426 million. However, funding for life sciences research and nuclear medicine applications would be down 23% to $38.6 million.

The other exception is what is called supporting research and technical analysis, funding for which would be up 5% to about $292 million. Within that category funding for basic energy sciences would be up overall 16% to nearly $283 million, with funding for chemical sciences up 11% to $75.9 million, and that for materials research up about 14% to $120 million.

Those increases reinforce the Administration's ongoing determination to redirect energy R&D programs to emphasize long-term research. The cuts in the other energy research areas emphasize the Administration's determination to rely on the private sector for technology development.

For example, fossil energy R&D funding would be down 83% to $107 million, primarily because the government is getting out of the business of demonstrating energy technologies. Much the same reasoning lies behind the 65% cut in the solar energy budget to about $159 million, and the 76% cut to $65.2 million in the conservation R&D budget.

The government plans to concentrate its fossil energy research efforts in areas such as instrumentation, environmental effects, coal chemistry, and catalysis. The solar program would focus on basic generic research in such areas as materials science and photobiology. In addition, $27 million would be provided for photovoltaic research but all remaining federally funded research on electric energy systems and energy storage systems would be phased out.

Even the nuclear programs, which the Administration specifically highlighted in a section of the budget entitled "Increasing Investment in Research and Development," would be cut back. The nuclear fission program would be cut 28% to $852 million and magnetic fusion 8% to about $433 million. The breeder reactor program would be cut 16%, even while the funding for the Clinch River breeder reactor would more than double to $254 million. The light water reactor program would be slashed 73% to $32 million, with part of the funding allocated for research at the damaged Three Mile Island nuclear plant.

There is one new initiative in the nuclear area. The Administration is requesting almost $180 million for R&D and site investigations for a terminal isolation nuclear waste repository. It also plans to ask Congress to enact legislation imposing a kilowatt-per-hour fee on nuclear electricity generators, which is expected to raise $300 million, to operate a permanent disposal site.

The Commerce Department's old-line research programs didn't fare much better than its new energy programs in the budget request. For example, funding for the National

The total federal R&D package

Agency by agency R&D funding breaks down like this

	Obligations			Outlays		
$ Millions	1983[a]	1982[a]	1981[b]	1983[a]	1982[a]	1981[b]
Defense	$24,489	$20,553	$16,494	$22,673	$18,784	$15,720
NASA	6,513	5,841	5,407	6,460	5,696	5,279
Commerce	4,157	4,793	5,276	4,352	5,240	5,466
HHS	4,122	3,972	3,973	4,039	3,935	3,991
NSF	1,033	961	964	908	1,018	892
USDA	838	807	773	824	805	742
Interior	371	397	424	380	402	438
Transportation	366	329	420	316	321	418
EPA	230	317	326	274	335	344
Nuclear Regulatory Commission	220	223	227	206	209	211
Agency for International Development	196	160	156	159	157	151
Veterans Administration	145	137	147	140	130	138
Education	76	74	91	112	94	96
Other	272	279	354	280	298	366
TOTAL	$42,998	$38,843	$35,032	$41,123	$37,424	$34,252

a Estimates. b Actual. Source: Office of Management & Budget

Funds for basic research would rise 9% to $5.8 billion

	Obligations			Outlays		
$ Millions	1983[a]	1982[a]	1981[b]	1983[a]	1982[a]	1981[b]
HHS	$2069	$2000	$1955	$2034	$1978	$1944
NSF	984	912	898	881	972	830
Defense	781	673	603	712	616	554
Commerce	762	665	608	759	670	614
NASA	682	580	532	661	575	538
USDA	359	332	314	354	327	302
Interior	68	73	80	69	73	79
Smithsonian	51	45	44	51	44	41
Veterans Administration	14	13	15	14	13	15
Education	14	14	17	22	18	16
EPA	10	15	10	10	12	12
Other	28	27	32	28	29	29
TOTAL	$5822	$5340	$5108	$5575	$5337	$4976

a Estimates. b Actual. Source: Office of Management & Budget

Federal funds for R&D facilities would fall 17%

	Obligations			Outlays		
$ Millions	1983[a]	1982[a]	1981[b]	1983[a]	1982[a]	1981[b]
Commerce	$ 681	$ 964	$ 982	$ 644	$1191	$1112
Defense	366	285	278	320	248	238
NASA	116	143	114	122	135	147
USDA	30	35	21	34	39	39
HHS	20	62	25	38	35	43
NSF	16	10	13	15	10	13
Other	33	28	47	25	43	35
TOTAL	$1262	$1527	$1480	$1198	$1701	$1627

a Estimates. b Actual. Source: Office of Management & Budget

Bureau of Standards would be cut 17% to $96.1 million, 5% less than was budgeted in fiscal 1981. Most of the cut is accounted for by the transfer of the governmentwide computer standards program to the General Services Administration. However, funding for central technical support would be down 23% to $17.4 million. Measurement research and standards would be cut 8% to $48.8 million. Funding for engineering measurements and standards, on the other hand, would be up slightly, 6%, to $29.9 million.

The National Oceanic & Atmospheric Administration's budget also would be down more than 8% to about $759 million. Its research budget is expected to fall about 5% to $152 million. Among other things, NOAA is terminating its aquaculture, underseas and ocean dumping research programs; reducing its research on climate and global atmosphere; but increasing its acid precipitation research program.

The National Aeronautics & Space Administration once again has the largest civilian commitment to R&D —$5.3 billion of the agency's $6.6 billion budget is slated for R&D, a 12.5% increase over the revised fiscal 1982 figures. NASA Administrator James M. Beggs believes this is a good increase during a time of tight budgets and readily admits that the budget was prepared based on the priorities of reviving the U.S. economy and strengthening national security.

It is hard to get an exact handle on NASA's budget because of the shifting status of its many ongoing programs. These are funded at different rates for different years, depending on their stage of completion and/or their importance. In general, in fiscal 1983 the space shuttle would get the largest share of the funding, while other projects would get the scraps.

Most of the R&D funds would go for space transportation; and that would be about evenly divided between space shuttle production and system improvements on one side and actual space shuttle operations on the other. The first operational flight of the shuttle is expected early in fiscal 1983, and the increased budget for this will make the shuttle "the workhorse of our civil and military efforts in space through the 1980s," Beggs says.

Space science R&D funding at NASA would rise 16.7% above the revised 1982 figure to $682 million in 1983. This area includes physics

How the agencies fare

NSF budget up 8% to over $1 billion . . .

$ Millions	1983[a]	1982[a]	1981[b]
Mathematical and physical sciences	$ 298.7	$272.9	$ 256.5
Astronomical, atmospheric, earth, and ocean sciences	259.7	240.0	236.3
Biological, behavioral, and social sciences	186.7	176.0	185.6
Engineering	99.7	92.0	86.3
Antarctic program	86.4	66.0	67.4
Program development and management	63.1	63.5	59.2
Scientific, technological, and international affairs	44.0	40.3	53.7
Science and engineering education	15.0	20.9	70.7
Minority institutions science improvement program	3.3	4.8	4.9
Special foreign currency program	2.2	4.6	4.0
TOTAL	$1058.8	$981.0	$1024.6

a Estimates. b Actual. Note: Obligations. Source: National Science Foundation

. . . with funding for chemistry up 9%

$ Millions	1983[a]	1982[a]	1981[b]	% change 1982–83
Physics	$ 88.5	$ 75.3	$ 72.1	17.5%
Physiology, cellular, and molecular biology	85.2	79.4	78.2	7.3
Ocean sciences	81.0	75.8	75.0	6.9
Materials research	80.9	80.0	76.2	1.1
Atmospheric sciences	74.8	70.0	69.3	6.9
Chemistry	66.1	60.7	57.6	8.9
Astronomical sciences	63.2	59.1	56.4	6.9
Environmental biology	45.0	42.0	41.0	7.1
Earth sciences	34.4	29.2	27.9	17.8
Mathematical sciences	33.9	31.2	28.3	8.7
Computer research	29.3	25.7	22.3	14.0
Chemical and process engineering	22.2	20.1	18.5	10.4
Behavioral and neural sciences	21.8	20.5	21.0	6.3
Social and economic sciences	17.8	17.6	25.1	1.1
TOTAL	$744.1	$686.6	$670.9	8.4%

a Estimates. b Actual. Note: Obligations. Source: National Science Foundation

Commerce's research budget down 26%

$ Millions	1983[a]	1982[a]	1981[b]
Energy Research & Technology Administration	$3759.8	$5104.7	$5152.6
Defense R&D and testing	1075.0	934.3	793.1
Nuclear fission	852.1	1196.4	1127.2
General science and research	601.0	536.0	503.4
Magnetic fusion	432.5	469.5	418.2
Supporting research	292.1	277.4	272.3
Conservation, solar and other renewables	231.2	858.5	983.5
Environment	169.0	219.5	236.2
Fossil energy	106.9	613.1	818.7
NOAA	152.0	159.0	201.0
NBS	96.1	116.5	101.0
Other	12.0	24.0	44.0
TOTAL	$4019.9	$5404.2	$5498.6

a Estimates. b Actual. Note: Obligations. Sources: Office of Management & Budget, Department of Energy

NASA gets 11% rise in total R&D funds

$ Millions	1983[a]	1982[a]	1981[b]
Conduct of R&D	$5334.0	$4736.0	$4334.3
Space shuttle	1718.0	2163.0	1995.0
Space flight operations	1707.0	895.9	679.2
Space tracking & data systems	508.9	402.1	339.9
Physics & astronomy	471.7	323.5	323.7
Space applications	316.3	325.8	331.5
Aeronautical research & technology	232.0	233.0	271.4
Planetary exploration	154.6	205.0	175.6
Space research & technology	123.0	111.0	110.7
Life sciences	55.7	39.5	42.2
Expendable launch vehicles	42.8	31.2	54.4
Technology utilization	4.0	8.0	8.8
Energy technology	—	—	1.9
Research and program management	1179.9	1144.7	1071.1
Construction of facilities	100.0	98.7	116.9
TOTAL	$6613.9	$5981.4	$5522.3

a Estimate. b Actual. Note: Obligations. Source: National Aeronautics & Space Administration

and astronomy, planetary exploration, and life sciences research. Specific projects slated for some funding increases include the space telescope (up $16 million to about $138 million), to be launched from the shuttle in 1985, and the international solar polar mission (up $16 million to $21 million), which was almost eliminated in last year's cuts. Funding for experiments in life sciences on the shuttle would get an increase of $14 million to $24 million for fiscal 1983, and the funds for payload development aboard the shuttle would more than double from $40 million to $81.4 million next year.

Funds for space applications R&D would fall somewhat, mostly because of a sharp drop in technology transfer funds, cuts in funds for payload development, materials processing in space aboard spacelab, and applied research in communications and information systems.

For the future, Beggs says the agency is looking at the possibility of unmanned space platforms in low Earth orbit or geosynchronous orbit, and at a permanently manned space facility in low Earth orbit.

The Department of Health & Human Services would get about $4.0 billion, a 4% increase, for R&D in the proposed budget, almost all of which would support research at the National Institutes of Health. The institutes are scheduled for a minuscule increase of less than $38.5 million, or 1.1%, to $3.5 billion. According to the Administration, this budget level would permit NIH to fund more than 15,000 research grants for 1983. But that may not occur. A year ago NIH officials were concerned about their ability to continue to grant that many awards, and now, with a budget increase below the rate of inflation, the number of grants may have to fall to keep them large enough to support high-quality research.

Among the individual institutes, funding for the Cancer Institute was cut 3% to $956 million and it was the only institute whose funding was actually reduced. Others received

NSF chemistry funding is broken down along these lines

$ Millions	1983[a]	1982[a]	1981[b]	% change 1982–83
Structural chemistry and thermodynamics	$13.3	$12.2	$11.7	9.0%
Chemical dynamics	13.0	11.9	11.2	9.2
Chemical physics	11.0	10.1	9.6	8.9
Synthetic organic and natural products chemistry	7.9	7.3	6.9	8.2
Synthetic inorganic and organometallic chemistry	7.6	7.0	6.6	8.6
Chemical analysis	7.5	6.9	6.6	8.7
Chemical instrumentation	5.8	5.3	5.1	9.4
TOTAL	$66.1	$60.7	$57.7	8.9%

a Estimates. b Actual. Note: Obligations. Source: National Science Foundation

Defense R&D up more than 20%

$ Millions	1983[a]	1982[a]	1981[b]
Tactical programs	$ 7,575.7	$ 6,899.7	$ 6,129.7
Strategic programs	6,647.1	4,586.4	3,440.4
Technology base	3,336.9	2,907.1	2,600.1
Program management and support	2,972.6	2,655.9	2,237.9
Intelligence and communications	2,772.5	2,202.0	1,832.1
Advanced technology development	951.7	735.4	593.3
TOTAL	$24,256.5	$19,986.5	$16,833.5

a Estimate. b Actual. Note: Obligations. Source: Office of Management & Budget

USDA research continues to increase

$ Millions	1983[a]	1982[a]	1981[b]
Agricultural Research Service	$ 470.5	$436.3	$420.5
Cooperative State Research Service	232.1	221.2	200.9
Extension Service	311.8	313.7	303.8
National Agricultural Library	9.0	8.3	8.4
TOTAL	$1023.5	$979.5	$933.6

a Estimate. b Actual. Note: Obligations. Source: Department of Agriculture

Small increase at NIH won't cover inflation

$ Millions	1983[a]	1982[a]	1981[b]
National Institutes	$3462.3	$3423.8	$3308.3
Cancer	955.9	987.1	989.5
Heart, Lung & Blood	577.3	559.8	550.1
Arthritis, Diabetes & Digestive & Kidney Disease	379.4	368.2	369.3
General Medical Sciences	345.6	339.9	333.5
Neurological & Communicative Disorders & Stroke	274.6	266.0	252.2
Allergy & Infectious Diseases	247.4	237.5	232.2
Child Health & Human Development	233.6	226.3	220.4
Environmental Health Sciences	157.8	154.6	96.6
Eye	131.5	130.4	117.7
Aging	84.6	81.9	75.6
Dental Research	74.6	72.1	71.2
Research Resources	192.3	185.4	176.6
National Institute for Occupational Safety & Health	40.5	60.3	102.4
National Library of Medicine	46.0	47.9	46.7
Office of the director	35.4	33.7	32.3
Research facilities	17.5	21.5	17.0
John E. Fogarty Center	12.7	11.7	9.6
TOTAL	$4008.0	$3784.3	$3692.9

a Estimate. b Actual. Note: Obligations. Source: Office of Management & Budget

Research at EPA takes another large drop

$ Millions	1983[a]	1982[a]	1981[b]
Air	$ 47.2	$ 55.7	$ 59.0
Energy	34.5	52.5	84.1
Hazardous waste	29.6	29.5	28.3
Water quality	27.7	45.1	49.9
Toxic substances	26.6	31.2	30.0
Drinking water	22.9	28.3	21.8
Program management	8.7	7.9	8.4
Pesticides	6.5	5.6	7.9
Superfund	6.4	13.9	4.7
Interdisciplinary	4.2	5.7	6.1
Radiation	1.6	2.5	2.4
TOTAL	$215.9	$277.9	$302.6

a Estimate. b Actual. Note: Obligations. Source: Environmental Protection Agency

small increases—from about $1 million for the Eye Institute to more than $17 million for Heart, Lung, & Blood.

The Administration lists some activities considered significant that would be undertaken by NIH for 1983. These include clinical trials of new antiviral drugs against herpes, basic research on diabetes, research on epidemiology and risk estimation, and test development on reproductive toxicology, fertility assessment, and neurological toxicology.

As National Science Foundation director John B. Slaughter says, "within the context of the President's overall budget plans, I feel the NSF budget is a strong one" albeit "tightly constructed." This tight budget means that projects of lesser scientific promise or urgency will have to be postponed, extended, or in some instances phased out in order to focus available resources on projects of the highest merit and potential significance, NSF warns. One project that is being terminated is the Ocean Margin Drilling program, because of lack of interest from the oil industry which was expected to share the cost of the program on an equal basis.

Overall, NSF's budget would be up 7.7% to $1.1 billion. Obligations for research and related activities would be up 8.7% to just under $1.1 billion. But the science and engineering education budget almost would be gone; it would be down 28% to $15 million. That amount would go solely for graduate fellowships and would support 1390 new and continuing fellows at an annual stipend of $6900, plus a cost of education allowance of $4000 per year.

There are no major new initiatives in NSF's proposed budget (in fact, it calls for a 5% reduction in NSF staff), but a number of old initiatives would continue to be supported. Although no separate instrumentation improvement budget was included as was proposed last January, NSF expects to increase its funding of major equipment purchases by 31% to $10.2 million.

Funding for other equipment and instrumentation would rise 9% to $85.1 million, slightly less than in fiscal 1981. For the most part, equipment purchases would be funded as part of regular research grants.

In addition, the proposed budget would provide for funding of one new industry/university cooperative research center, bringing the total to six; a 9% increase to $6 million in funding for industry/university cooperative research projects; a 10% increase to $5.5 million for small business innovation research; and a 50% increase in the minority research initiation program, to $2.5 million.

Funding for the mathematical and physical sciences directorate would be up 9.5% to almost $299 million, with funding for chemical research up 8.9% to $66.1 million. The $5.4 million increase would be spread fairly evenly among all the chemistry program areas. Within the directorate, overall support for individual project research would be increased about 8% to maintain approximately a constant level of effort across all disciplines.

Within the biological, behavioral, and social sciences directorate, funding for the social and economic sciences, which was scheduled to be terminated and then was rescued last year, would be held essentially level at $17.8 million, 30% less than was provided in fiscal 1981.

The Department of Agriculture is the sixth largest federal funding agency for R&D under the proposed fiscal 1983 budget. With just over $1 billion for R&D next year, the Administration would give USDA a 4.5% hike over the 1982 figure. Agriculture is also one of the few R&D agencies whose funding would not be cut back from 1982 revisions made by the Administration. The proposed increase for 1983 shows there is an ongoing commitment to agricultural research, much of it in basic research, but there would be some changes in emphasis.

The largest portion of the funds would go to USDA's in-house research program, the Agricultural Research Service. ARS support is proposed at almost $471 million for 1983, an 8% increase above fiscal 1982. Most of the ARS work is in basic and developmental research in cooperation with the state experiment stations. Major programs for 1983 would include improvement of plant and animal production efficiency, use and improvement of natural resources, and protection of plants and animals from pests. An area slated for a large increase is research on acid precipitation, surging from only $110,000 in fiscal 1982 to just under $1 million for 1983. The only cutback at ARS would be in tropical and subtropical research, dropping 80% to $735,000 in 1983.

A smaller net gain has been proposed for USDA's cooperative state research service. Nearly $11 million would be added, raising the total to $232 million. These funds are mostly handed out by a formula to land-grant universities to do agricultural research. The competitive grants portion of the program, however, would get a big increase—up 40% to $22.9 million in 1983. Much of this would be targeted to basic plant science. Also included in the budget would be about $9 million for improvement of research equipment and facilities at the 17 land-grant colleges and the Tuskegee Institute—the first installment of a five-year, $50 million program.

The third major section of USDA's R&D work is the extension service, which acts like a technology clearinghouse for farm, local, and community agriculture problems. A small decrease in funding is proposed for this work, down $1.8 million to $312 million for fiscal 1983. This small change may reflect the beginning of an Administration move to get the states to fund more of this kind of service in the future.

R&D funding at the Environmental Protection Agency has been the subject of intense speculation for months. And even with Administration figures, the impact of the changes is not clear. Different numbers from OMB and EPA for what R&D funding will be, different starting figures because of fiscal 1981 rescissions and deferrals and fiscal 1982 multiple revisions make it very hard to get a handle on what the true figures are.

But, whatever yardstick is used, the trend is down—way down. EPA says its R&D budget would be 23.3% lower for 1983 than in 1982, to $216 million. The fiscal 1982 number was the subject of much trimming last year, as was the fiscal 1981 R&D budget. Just about every category would have reduced funding. Only funding for hazardous waste research, a kind of showplace for the Administration, would stay the same at $30 million. Pesticide research funding, however, would increase 16% to $6.5 million.

According to EPA, this reduced R&D program still would permit the agency to fulfill the needs of the laws it administers. This can be done, EPA officials claim, because of a shift in the attitude toward research at EPA. From now on, EPA's research will be directed only toward meeting its regulatory needs, it says. In other words, research not immediately useful to EPA will be eliminated. An example of this would be large reductions in funds for air quality modeling research because, EPA says, the models being developed were much too complex for the needs of the states using them.

One justification given for lower funding is that additional research in some areas is no longer needed by EPA. Examples cited include a much slower pace for research on pollution from synthetic fuels plants and the expected completion of some conventional combustion technology projects in fiscal 1982. Other reasons are the completion of an epidemiology program in the drinking water area and the expected end to research on effluent guidelines and priority pollutants in water. Superfund research also is slowing, with a $7.5 million reduction set for 1983 because of the fast startup of that program and the assumption that the development of cleanup protocols for abandoned waste dumps will be finished this year.

Responding to some persistent rumors of mass firings at EPA in 1982 that would completely gut the agency, EPA Administrator Anne M. Gorsuch wrote to all EPA staff members that there would be no involuntary terminations at EPA for the rest of fiscal 1982. Still, EPA is counting on continuation of its high rate of attrition to get down to about 8700 employees, a drop of almost 1200 from 1981. R&D staff is expected to lose about 250 permanent employees before fiscal 1983, leaving a total of 1300. It is curious, however, that during a time of reductions in staff and claims that the agency is topheavy with management, that the budget for R&D program management could rise 10% as the rest of the R&D budget falls.

Congress of course will alter the proposed budget figures before they are made final, but there is hope in Washington that the Administration will not keep changing the game plan as it did last year. And it is not likely to. This budget is the Reagan Administration's product from start to finish. However, if the size of the deficit prompts Congress to take up the budget ax, then those programs which got increases when others didn't offer tempting targets. □

New recession torpedoes chemical earnings

An unexpected economic dip hit an already weakened U.S. chemical industry in fourth quarter, triggering at least six months of poor profits

William J. Storck, C&EN, New York, and William F. Fallwell, C&EN, Washington

The U.S. chemical industry has been dealt a severe economic blow. Just as it had begun to recover last year from the 1980 recession, the industry was hit in the fourth quarter by a new recession that was unexpected, worldwide, and very damaging.

Many chemical companies and product lines escaping trouble in 1980 were trapped the second time. The new recession shows every sign of extending at least through the first quarter of 1982.

The outcome has been a sharp change in the chemical industry's financial results beginning with the final three months of 1981. After managing two quarters of improved year-to-year earnings, basic chemical companies headed back into declining figures in the fourth quarter.

As a result, full-year 1981 earnings hardly budged from 1980, coming in lower than the most pessimistic forecasts and embarrassingly wide of the more optimistic targets. The profits outlook for 1982 is more of the same, at least through mid-year. All talk of recovery in the industry starts with the second half.

So the chemical and most other U.S. industries indeed now have their "double dip," the repeat recession forecast by a few maverick economists a year ago and widely derided in business circles. The main trigger was a renewed interest-rate spiral, especially painful for big-ticket consumer durables markets such as autos and housing. However, the financial impact on chemicals was exacerbated by chemicals' own problems of low plant capacity use, heavy price discounts, a reversal in foreign trade, and, to the surprise of many, excessive plant investment.

The main question now is, when will all this bottom out? Straws from the heart of the chemical industry this winter show only further decline, although production sources hope that the slide will end by spring. A telltale sign is renewed weakness in man-made fibers, an early warning product group, after some reports of firming around year's end. More indications of continuing poor business are drastically discounted prices in major products, including basic olefins, aromatics, plastics, and fertilizer. These clues are borne out by the first

Chemical industry leaders for fourth quarter . . .

Sales				Earnings[a]			Profitability		
Rank		$ Millions	Rank 1980		$ Millions	Rank 1980		Earnings as % of sales	Rank 1980
1	Du Pont[b]	$3440.0	1	Du Pont[b]	$159.0	1	Freeport-McMoRan	15.3%	1
2	Dow Chemical	2985.0	2	Union Carbide	139.8	3	Nalco Chemical	12.0	2
3	Union Carbide	2430.0	3	Allied Corp.	92.0	4	International Flavors	11.1	3
4	W. R. Grace	1759.3	4	W. R. Grace	81.7	5	Petrolite	9.9	4
5	Allied Corp.	1696.0	6	Dow Chemical	66.5	2	Air Products	9.3	5
6	Monsanto	1558.2	5	Diamond Shamrock	59.7	7	Loctite	7.6	9
7	American Cyanamid	927.1	7	Monsanto	51.8	9	Diamond Shamrock	6.8	13
8	Celanese	884.0	8	American Cyanamid	48.4	8	International Minerals	6.8	8
9	Diamond Shamrock	872.5	9	PPG Industries	39.1	6	Stauffer Chemical	6.6	13
10	PPG Industries	803.8	10	Celanese	35.1	10	First Mississippi	6.5	7

. . . and for full-year 1981

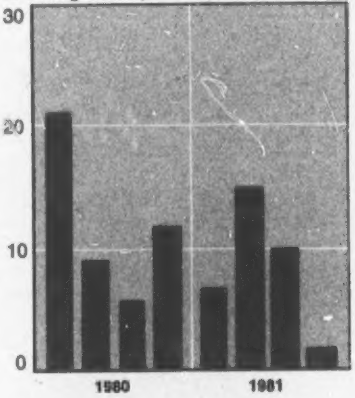
Sales				Earnings[a]			Profitability		
Rank		$ Millions	Rank 1980		$ Millions	Rank 1980		Earnings as % of sales	Rank 1980
1	Du Pont[b]	$14,700.0	1	Du Pont[b]	$797.0	1	Freeport-McMoRan	19.0%	1
2	Dow Chemical	11,872.7	2	Union Carbide	649.0	3	International Flavors	14.6	2
3	Union Carbide	10,170.0	3	Dow Chemical	563.5	2	Nalco Chemical	12.2	3
4	Monsanto	6,947.6	4	Monsanto	377.5	6	Petrolite	9.4	4
5	W. R. Grace	6,520.8	5	Allied Corp.	343.0	4	Stauffer Chemical	8.7	10
6	Allied Corp.	6,407.0	6	W. R. Grace	326.4	5	Air Products	8.1	8
7	Celanese	3,752.0	8	Diamond Shamrock	230.2	7	Diamond Shamrock	6.8	11
8	American Cyanamid	3,649.1	7	PPG Industries	211.2	8	First Mississippi	6.8	6
9	PPG Industries	3,400.0	9	American Cyanamid	197.1	11	Union Carbide	6.4	12
10	Diamond Shamrock	3,376.2	10	Freeport-McMoRan	159.0	10	PPG Industries	6.2	14
							Loctite	6.2	7

a After taxes. b Excludes Conoco. **Note:** For 40 chemical companies listed on page 18.

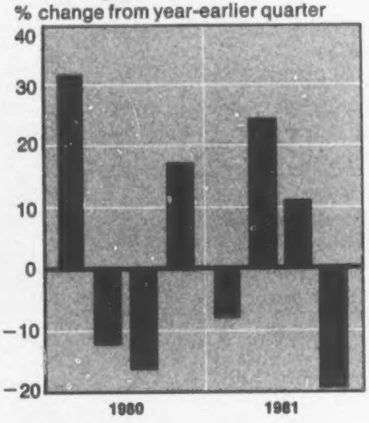
Chemical industry 1981 fourth-quarter results

- Sales were almost flat
- Earnings fell
- Profit margins dropped
- Production slipped 4.6%
- Prices rose 9.8%

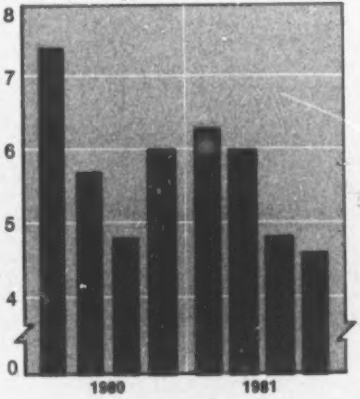
Sales
% change from year-earlier quarter



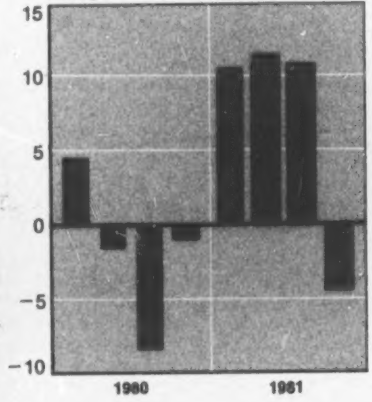
Earnings
% change from year-earlier quarter



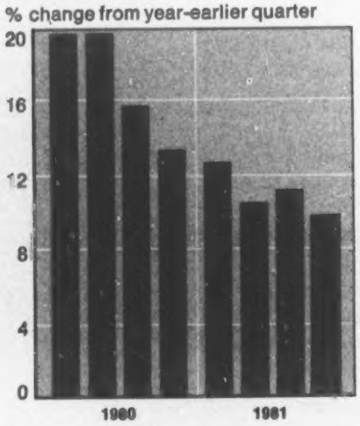
Profit margins
After-tax earnings as % of sales



Production
% change from year-earlier quarter

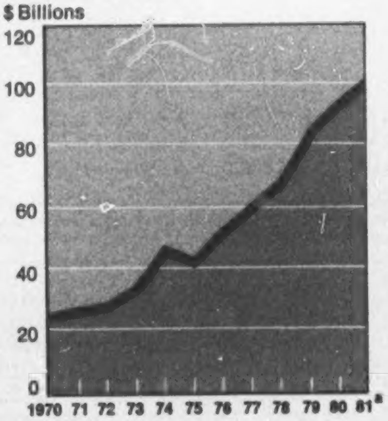


Prices
% change from year-earlier quarter

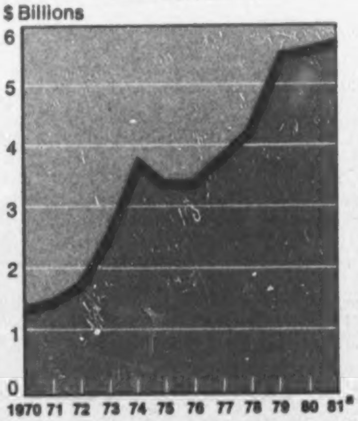


Sales increased 7% in 1981 to top $100 billion; earnings were almost flat; and profit margins decreased to 5.6%

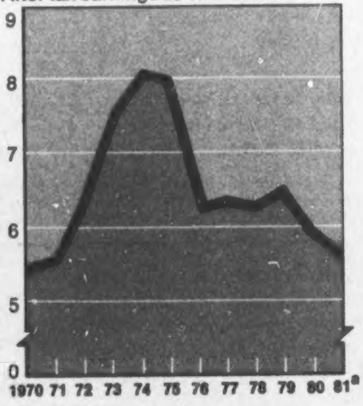
Annual sales
$ Billions



Annual earnings
$ Billions



Annual profit margins
After-tax earnings as % of sales



a C&EN estimates. **Note:** All sales, earnings, and profit margin data are based on the combined performance of the 40 largest chemical makers listed on page 18.

Earnings at chemical companies took a drubbing in fourth-quarter 1981

	FOURTH-QUARTER 1981						FULL-YEAR 1981			
	Sales	Earnings	Change from 1980		Profit margin[a]		Sales	Earnings	Change from 1980	
	($ millions)		Sales	Earnings	1981	1980	($ millions)		Sales	Earnings
Du Pont[d]	$ 3,440.0	$ 159.0	−2%	−18%	4.6%	5.5%	$ 14,700.0	$ 797.0	7%	17%
Dow Chemical	2,985.0	6[illegible].5	8	−73	2.2	8.7	11,872.7	563.5	12	−30
Union Carbide	2,430.0	139.8	−9	−6	6.0	5.6	10,170.0	649.0	2	−4
W. R. Grace[e]	1,759.3	81.7	3	20	4.6	4.0	6,520.8	326.4	6	26
Allied Corp.[f]	1,696.0	92.0	17	−4	5.4	6.6	6,407.0	343.0	16	13
Monsanto[g]	1,558.2	51.8	−6	31	3.3	2.4	6,947.6	377.5	6	47
American Cyanamid	927.1	48.4	1	nc	5.2	5.3	3,649.1	197.1	6	24
Celanese	884.0	35.0	−3	−10	4.0	4.3	3,752.0	144.0	12	18
Diamond Shamrock	872.5	59.7	3	9	6.8	6.4	3,376.2	230.2	7	8
PPG Industries	803.8	39.1	−5	−42	4.9	8.0	3,400.0	211.2	6	1
B. F. Goodrich[h]	—	—	—	—	—	2.9	—	—	—	—
Hercules[i]	649.0	27.4	3	−12	4.2	4.9	2,718.0	147.4	9	29
Olin[j]	445.2	13.8	−5	10	3.1	2.7	2,001.3	92.8	7	26
Ethyl Corp.	430.3	23.9	nc	−3	5.6	5.7	1,757.2	90.9	1	1
Williams Cos.[k]	423.9	6.1	−15	−81	1.4	6.4	1,976.3	99.2	−5	−28
Rohm & Haas	412.5	13.9	−1	−18	3.4	4.1	1,884.7	96.8	9	3
International Minerals[l]	409.1	28.0	−17	−33	6.8	8.4	1,940.8	144.7	nc	−17
Stauffer Chemical[m]	376.5	24.7	−12	−10	6.6	6.4	1,726.2	149.9	2	24
Air Products[n]	373.6	34.6	2	7	9.3	8.8	1,577.2	128.3	7	10
Witco Chemical	306.7	11.2	−2	1	3.7	3.3	1,291.9	38.6	10	6
Akzona	276.5	−2.2	−1	def	def	0.7	1,187.6	11.6	13	138
Pennwalt	250.5	−2.7	−5	def	def	4.1	1,056.1	36.7	1	−7
Reichhold Chemicals	210.9	1.5	−5	−79	0.7	3.2	950.0	17.1	7	6
Lubrizol[h]	—	—	—	—	—	10.7	—	—	—	—
Freeport-McMoRan	199.8	30.6	5	−21	15.3	20.2	835.4	159.0	19	−2
Thiokol[h]	—	—	—	—	—	4.5	—	—	—	—
Nalco Chemical	177.6	21.3	9	6	12.0	12.4	666.6	81.2	8	12
Mallinckrodt[h]	—	—	—	—	—	3.5	—	—	—	—
International Flavors	97.9	7.6	2	−28	7.8	11.1	451.1	66.1	1	5
Liquid Air[h]	—	—	—	—	—	6.3	—	—	—	—
Chemed[h]	—	—	—	—	—	7.4	—	—	—	—
First Mississippi	95.6	6.2	−3	−26	6.5	8.5	350.1	23.7	19	−7
H. B. Fuller Co.	82.4	3.2	5	8	3.9	3.8	328.7	13.6	11	53
Petrolite	77.1	7.6	20	29	9.9	9.2	297.2	27.8	17	12
Crompton & Knowles	56.6	2.7	−7	8	4.8	4.1	243.4	8.6	1	12
Loctite	52.7	4.0	nc	−7	7.6	8.1	219.5	13.5	8	−21
Stepan Chemical[h]	—	—	—	—	—	3.2	—	—	—	—
Essex Chemical[h]	—	—	—	—	—	4.3	—	—	—	—
Great Lakes Chemical[h]	—	—	—	—	—	15.6	—	—	—	—
Philip A. Hunt	29.6	−0.8	11	def	def	def	111.9	3.8	5	−5
Total 19 largest companies	$21,182.7	$ 956.6	−0.8%	−21.9%	4.5%	5.7%	$87,669.0	$4827.5	7.1%	3.3%
Total 12 other companies	$ 1,607.2	$ 79.0	0.8%	−29.8%	4.9%	7.1%	$ 6,697.7	$ 462.7	9.0%	3.7%
GRAND TOTAL	$22,789.9	$1035.6	−0.7%	−22.6%	4.5%	5.8%	$94,366.7	$5290.2	7.3%	3.3%

a After-tax income as percentage of sales. b Fully diluted before nonrecurring items and extraordinary charges for operations. c As of Jan. 29. d Excludes Conoco results. e Excludes $34.9 million nonrecurring gain for 1981. f Excludes $33 million nonrecurring gain for fourth-quarter 1981, $5 million nonrecurring gain for full-year 1981, and $14 million nonrecurring loss in fourth-quarter 1980. g Excludes nonrecurring $67.7 million gain for 1981. h Not all information available at press time. i Excludes nonrecurring loss of $9.4 million in fourth-quarter 1981.

systematic survey of 1982 from the National Association of Purchasing Management, which finds that January brought further, although slower, decline than the previous few months.

In the fourth quarter, the bottom dropped out for the 31 U.S. chemical companies that have reported so far of the 40 largest chemical firms tracked by C&EN. Combined sales for the 31 dropped almost 1% to $22.8 billion in the fourth quarter. However, earnings for the 31 plunged 23% to $1.04 billion. As a result, profit margins for the group sank to 4.5% from 5.8% in the final three months of 1980.

It is almost surprising that the earnings and sales drops were not greater than they were, considering the breadth of poor results among the chemical companies that have reported. Of the 31, sales of 16 of them fell, and earnings of 20 of them dropped. The falling sales ranged from 1% at Rohm & Haas and Akzona to 17% at International Minerals & Chemical. The earnings decline was even more pronounced, ranging from

FULL-YEAR 1981		STOCK MARKET DATA[c]							
Profit margin[a]		Earnings per share[b]			Recent 12 months		Price earnings ratio Jan. 29	Annual indicated dividend	Dividend yield, % of price
1981	1980	4th qtr	Recent 12 months	Jan 29	High	Low			
5.4%	5.0%	na	na	$36¼	$56	$35⅛	na	$2.40	6.6%
4.7	7.6	$0.35	$3.00	24¼	39	23¼	8	1.80	7.4
6.4	6.7	2.04	9.56	47¼	62⅛	45¼	5	3.40	7.2
5.5	4.7	1.68	6.72	45¼	54⅞	38½	7	2.60	5.7
5.4	5.5	2.28	9.03	43¾	59⅞	39	5	2.40	5.5
5.4	3.9	1.25	9.75	68⅞	87½	59½	7	3.80	5.5
5.4	4.6	1.01	4.11	27½	36½	24½	6	1.75	6.4
3.8	3.6	2.05	8.52	54½	69¼	51⅜	6	4.00	7.3
6.8	6.8	0.96	3.68	24⅛	39⅝	23	7	1.76	7.3
6.2	6.5	1.15	6.34	33⅜	58¼	31½	5	2.36	7.1
—	2.0	—	—	20⅝	28⅛	18½	5	1.56	7.6
5.4	4.6	0.65	3.36	20⅞	26⅜	19⅛	6	1.32	6.3
4.6	4.0	0.59	3.88	21¾	27	19⅜	6	1.20	5.5
5.2	5.2	1.20	4.56	21⅜	34½	20	5	1.50	7.0
5.0	6.7	0.21	3.67	28⅜	46⅜	22¼	8	1.20	4.2
5.1	5.4	1.08	7.51	57	71¾	51⅞	8	2.80	4.9
7.5	9.0	1.05	5.31	31½	64	30⅜	6	2.60	8.3
8.7	7.2	0.56	3.41	21¾	27¾	18¾	6	1.32	6.1
8.1	7.9	1.21	4.50	35⅛	48⅞	32½	8	0.80	2.3
3.0	3.5	1.20	4.14	23¼	31½	22⅜	6	1.80	7.7
1.0	0.5	−0.18	0.95	10½	15½	9¼	11	0.80	7.6
3.5	3.8	−0.26	3.55	24¾	36	24¼	7	2.20	8.9
1.8	1.8	0.12	2.04	11⅛	16	10⅝	5	0.48	4.3
—	12.1	—	—	23½	35½	20⅜	12	1.08	4.6
19.0	23.1	0.44	2.30	21⅛	40½	18	9	0.60	2.8
—	4.6	—	—	29¾	39	26½	10	1.10	3.7
12.2	11.7	1.07	4.04	49¼	58¼	41	12	2.00	4.1
—	8.1	—	—	47½	49⅜	31½	14	1.00	2.1
14.6	14.1	0.21	1.81	19½	22⅜	17⅞	11	1.00	5.1
—	7.2	—	—	16½	29¼	16½	7	1.60	9.7
—	8.8	—	—	23¼	25⅛	19	8	1.14	4.9
6.8	8.7	0.29	1.11	13⅛	24⅞	12⅛	12	0.24	1.8
4.1	3.0	0.70	2.97	21¾	26½	13	7	0.48	2.2
9.4	9.8	0.64	2.33	24¼	24¼	16½	10	1.20	4.9
3.5	3.2	0.78	2.51	17	18¾	13½	7	1.04	6.1
6.2	8.7	0.40	1.36	22¼	30	18⅛	16	0.56	2.5
—	2.3	—	—	16⅜	21⅞	13⅛	5	—	—
—	3.6	—	—	16¾	20¼	13½	6	0.80	4.8
—	14.9	—	—	37¾	58½	34⅜	14	0.48	1.3
3.3	3.8	−0.15	0.67	9½	12⅛	8⅜	14	0.40	4.2
5.5%	5.7%								
6.9%	7.3%								
5.6%	5.8%								

j Excludes nonrecurring charge of $40 million in fourth-quarter 1980. k Excludes nonrecurring charge of $3.7 million in 1981. l Excludes nonrecurring gain of $41.3 million in fourth-quarter 1981. m Excludes nonrecurring gain of $14.9 million in fourth-quarter 1980. n Excludes $81.9 million nonrecurring gain in fourth-quarter 1981. def = deficit. na = not applicable. nc = no change.

a drop of just 3% at Ethyl Corp. to 73% at Dow Chemical and 79% at Reichhold Chemicals to losses at Akzona, Pennwalt, and Philip A. Hunt.

Oddly, the drops in earnings were less pronounced at the 19 largest (and usually more basic) chemical companies than among the smaller, more specialty-oriented companies. The larger companies had a combined earnings fall of about 22% from the year-earlier quarter to $957 million. This was on an almost 1% reduction in sales to $21.2 billion.

The 12 smaller companies, dragged down by the losses at Akzona, Pennwalt, and Philip A. Hunt, showed a fourth-quarter earnings drop of 30% to $79.0 million. Sales for the smaller group increased, but only 0.8% to $1.61 billion.

As a result of the poor showing in the fourth quarter, chemical companies had a lackluster year, with profits increasing only slightly. Combined earnings for the 31 chemical companies increased only 3.3% in 1981 to $5.29 billion. Sales during the year climbed about 7.3% to $94.4 bil-

Earnings slump at many chemical-producing oil and gas companies

	% chemical sales	FOURTH-QUARTER 1981 Sales	Earnings	Change from 1980 Sales	Earnings	Profit margin[a] 1981	1980	FULL-YEAR 1981 Sales	Earnings	Change from 1980 Sales
		(% millions)						($ millions)		
Exxon	7%	$29,583.0	$1065.0	−1%	−21%	3.6%	4.5%	$114,989.0	$5565.0	4%
Mobil[b]	3	18,024.0	588.0	4	5	3.3	3.2	68,516.0	2434.0	8
Texaco[b]	3	14,700.0	507.0	4	1	3.4	3.5	59,400.0	2310.0	13
Standard Oil of California	3	11,900.0	571.0	10	−7	4.8	5.7	45,200.0	2380.0	9
Gulf Oil[b]	10	7,957.0	301.0	4	−1	3.8	4.0	30,461.0	1231.0	6
Standard Oil (Ind.)[b]	9	7,800.0	384.0	1	−5	4.9	5.2	31,700.0	1841.8	14
Atlantic Richfield[b]	8	7,140.3	469.8	−3	18	6.6	5.4	28,208.3	1671.3	17
Shell Oil	16	5,193.0	458.0	1	12	8.8	8.0	21,739.0	1701.0	9
Sun Co.[b]	3	4,400.0	149.0	7	62	3.4	2.2	16,000.0	642.0	21
Tenneco	12	4,292.0	260.0	18	30	6.1	5.5	15,462.0	813.0	17
Phillips Petroleum	14	4,090.0	186.5	6	−35	4.6	7.4	16,290.0	879.4	19
Standard Oil (Ohio)	4	3,704.4	477.8	21	0	12.9	15.5	13,810.9	1946.9	22
Getty Oil	2	3,472.8	216.5	17	3	6.2	7.1	13,251.6	856.9	27
Union Oil[b]	10	2,911.2	236.0	8	33	8.1	6.6	11,296.0	767.0	8
Cities Service[b]	7	2,223.9	31.4	7	−73	1.4	5.7	8,564.4	286.4	15
Kerr-McGee	14	1,072.7	66.0	13	27	6.2	5.5	3,826.4	211.1	10
American Petrofina	15	531.2	17.0	−14	−12	3.2	3.1	2,522.2	47.1	20

a After-tax income as percentage of sales. b Excludes major nonrecurring earnings: Mobil—$459 million in first-quarter 1980; Texaco—$402 million in first-quarter 1980; Gulf Oil—$100 million in second-quarter 1980; Standard Oil (Ind.)—$80 million in third-quarter 1981; Atlantic Richfield—$115 million in third-quarter 1980; Sun Co.—$299 million in fourth-quarter

lion. Profit margins fell to 5.6% from 5.8% in 1980.

Unlike the fourth quarter, for the full year the smaller companies did a little better than the larger companies. Combined earnings for the 12 smaller firms were up 3.7% from 1980 to almost $463 million. Combined sales for the smaller companies increased 9.0% to $6.70 billion. But, because sales were increasing much faster than earnings, profitability fell. Profit margins for the smaller firms in 1981 averaged 6.9%, compared to 7.3% in 1980.

At the 19 larger firms, combined earnings increased 3.3% from 1980 to about $4.83 billion. Sales, meanwhile, rose 7.1% to about $87.67 billion. But, again, profit margins sank—to an average of 5.5% in 1981 from 5.7% the year before.

The main problems in the fourth quarter seem to be plastics, fibers, and foreign trade, including both declining export volumes and a negative impact on earnings in bringing money into the U.S. because of the higher value of the dollar against other currencies.

For instance, Allied Corp. indicates that income in the fibers and plastics area was sharply lower than in 1980 as a result of depressed housing and auto markets. Allied's earnings dropped 4% in the fourth quarter to $92 million, but sales increased 17% to almost $1.70 billion. However, income from fibers and plastics operations declined 59% in the fourth quarter to $9 million, and sales for these products dropped a more modest 11% to $271 million.

Dow Chemical, which suffered a whopping earnings drop of 73% to $66.5 million in the fourth quarter, also singled out low operating rates and poor pricing in plastics as one of its major problems in the final three months of 1981.

Fibers, seemingly always on the edge of a turnaround but never quite getting there, came in for their share of problems in the fourth quarter. For instance, the poor fibers market contributed mightily to the $2.2 million loss at Akzona in the fourth quarter.

And fibers aided the drop in earnings at Celanese. Overall, earnings at Celanese in the fourth quarter dropped 10% from the year before to $35 million.

Celanese's fiber earnings in the U.S. fell 18% in the fourth quarter to 71 cents a share, but overseas the situation was much worse. There Celanese's fiber earnings dropped to 6 cents a share from 16 cents a share in fourth-quarter 1980—a decline of almost 63%.

Only at Monsanto did fiber earnings seem to improve in the fourth quarter, but it was a case of the loss not being so great as it was the year before. The company had a loss on textile operations in the fourth quarter of $26.4 million, compared with a much greater loss of nearly $147 million in the fourth quarter of 1980.

The fertilizer markets, as they have in previous quarters, also contributed to lower earnings. At Freeport-McMoRan, agricultural minerals earnings fell about 25% in the fourth quarter, according to the company, principally as a result of a drop in sulfur sales of about 30% or 220,000 tons. Freeport also says that the U.S. chemical phosphate industry was operating at only about 66% of capacity in the fourth quarter, because of an intense cost-price squeeze on U.S. farmers.

And at Williams Cos. poor phosphate markets have hit the Agrico Chemical Co. subsidiary hard. For the full year, Agrico's operating profit declined to $35.1 million from $175.5 million in 1980.

The financial trouble for basic chemical companies in C&EN's fourth-quarter survey also spread to the rest of the chemical production sphere, including oil and other companies that are diversified into chemicals. Oil companies already had problems in both chemical and overall corporate performance before the fourth quarter. The other diversified chemical producers found the going much tougher in the fourth quarter than in their widely improved third quarter.

For 17 major chemical-producing oil and natural gas companies in

FULL-YEAR 1981			STOCK MARKET DATA							
Change from 1980	Profit margin[a]		Earnings per share		Stock price			Price-earnings ratio Jan. 29	Annual indicated dividend	Dividend yield, % of price
				Recent		Recent 12 months				
Earnings	1981	1980	4th qtr	12 months	Jan. 29	High	Low			
−2%	4.8%	5.1%	$1.22	$6.43	30⅝	39¼	29⅜	5	$3.00	9.8%
−13	3.6	4.4	1.38	5.72	23¾	39	22⅛	4	2.00	8.4
3	3.9	4.3	1.96	8.75	31½	43⅞	30⅛	4	3.00	9.5
−1	5.3	5.8	1.67	6.96	36½	51¾	34¾	5	2.40	6.6
−6	4.0	4.5	1.60	6.37	31⅞	41⅜	29⅞	5	2.80	8.8
−4	5.8	6.9	1.29	6.29	45⅞	75½	43½	7	2.80	6.1
9	5.9	6.4	1.86	6.66	43	62¾	38¼	6	2.40	5.6
10	7.8	7.7	1.48	5.51	40	51½	35¼	7	1.80	4.5
−18	4.0	5.9	1.19	5.13	37½	48¾	29	7	2.10	5.6
12	5.3	5.5	1.91	6.01	31⅞	49¾	28¾	5	2.60	8.2
−18	5.4	7.8	1.23	5.78	39	56	33¾	7	2.20	5.6
7	14.1	16.0	1.94	7.92	35¾	65¾	34⅛	5	2.40	6.7
−2	6.5	8.5	2.63	10.42	61	88¾	55⅛	6	2.40	3.9
19	6.8	6.2	1.36	4.42	34⅞	45⅝	28¼	8	1.00	2.9
−43	3.3	6.7	0.43	3.50	37¾	69⅛	35¼	11	1.60	4.2
16	5.5	5.2	1.27	4.07	38	43¾	30¾	10	1.10	2.9
−29	2.9	5.0	1.58	6.88	60	71⅞	41	8	3.20	5.3

1981, $135 million in second-quarter 1981, and a $62 million charge in fourth-quarter 1980; Union Oil—$24.4 million in second-quarter 1981; Cities Service—$290 million charge in fourth-quarter 1981.

Petrochemical earnings plummeted in the fourth quarter

Petrochemicals are, so to speak, the chemical industry's financial accent mark. They frequently copy the rest of the industry's performance, but in italics. When the chemical industry is up, petrochemicals are *really* up. And when the industry is down, petrochemicals are *really* down.

Given this tendency, petrochemical results in the fourth quarter are no mystery. If the leading basic chemicals companies were reporting earnings declines, petrochemicals were almost guaranteed a bath. And they got one.

Petrochemical earnings slumped a combined 69% in the fourth quarter from a year before at five leading U.S. oil companies supplying after-tax data. For all of 1981, earnings dropped 36%. That's disheartening for several reasons. Petrochemical earnings had shown their first signs of life in a year this past summer, nearly holding their own from the previous third quarter. That was major improvement after declines of 18% in the second quarter and 55% in the first quarter.

If the statistics weren't bad enough, petrochemicals' profits pinch hurts from a strategic (long-run) point of view. Oil companies' petrochemical operations are the largest part of chemical production outside basic chemical companies. Trouble here means that a large part of chemical investment isn't paying off. Thinking ran a few years ago that by now bedrock chemicals such as these should be close to a desirable return on investment following several years of restrained new-plant spending and restored economic growth. Unfortunately, this timetable has been seriously delayed, and chemicals are ailing at some of the nation's largest companies.

To start with the biggest company of all, Exxon had a physical volume decline in chemicals of 5% in 1981 from recessionary 1980, says chairman Clifton C. Garvin Jr. Because of "soft market conditions worldwide," this drop led to chemical earnings downswings of 44% in the fourth quarter and 34% for the year. Garvin adds that the main damage came outside the U.S. "Most of the earnings decline occurred in Europe and Canada, where profit margins were affected significantly by excess capacity and rising costs."

Mobil, with chemical earnings drops of 39% in the fourth quarter and 23% for the year, echoes Exxon's remarks about poor performance in Europe and adds that earnings also were lower for petrochemicals in the U.S.

Even worse off, Gulf Oil says that its chemicals had an operating (pretax) earnings loss of $34 million in 1981 after a profit of $126 million in 1980. "Losses were even greater in the U.S., where sales volumes and prices eroded in the face of industry overcapacity and deterioration in such major markets as autos and housing."

In much the same shape, Atlantic Richfield reports a pretax loss of $11 million on its chemicals in the fourth quarter and earnings of just $16 million for the year, down from $133 million in 1980. Elaborating on specific chemical production poundage, Arco says that olefins were down 50% year-to-year in the fourth quarter, aromatics down 11%, and polymers down 29%.

	AFTER-TAX EARNINGS					
	Fourth quarter			Full year		
$ Millions	1981	1980	% change	1981	1980	% change
Exxon	$44.0	$ 75.0	−44%	$266.0	$402.0	−34%
Mobil	22.0	36.0	−39	92.0	119.0	−23
Shell Oil	−11.0	18.0	def	24.0	128.0	−81
Standard Oil (Ind.)	−9.4	28.6	def	101.0	144.4	−30
Texaco	13.0	29.0	−53	75.0	77.0	−2
TOTAL	$58.6	$186.6	−69%	$558.0	$870.4	−36%

def = deficit.

Earnings also weaken at many diversified chemical producers

		FOURTH-QUARTER 1981						FULL-YEAR 1981		
	% chemical sales	Sales ($ millions)	Earnings ($ millions)	Change from 1980 Sales	Change from 1980 Earnings	Profit margin[a] 1981	Profit margin[a] 1980	Sales ($ millions)	Earnings ($ millions)	Change from 1980 Sales
General Electric	4%	$7560.0	$452.0	9%	11%	6.0%	5.9%	$27,240.0	$1652.0	9%
U.S. Steel[b,c]	12	3283.3	101.8	−4	−46	3.1	5.6	13,940.5	672.6	12
Procter & Gamble[b]	4	2900.0	191.0	5	21	6.6	5.6	11,600.0	730.0	4
Dart & Kraft[b]	11	2635.3	77.4	8	−20	2.9	4.0	10,211.0	413.3	8
3M	15	1577.0	161.0	5	−4	10.2	11.1	6,508.0	673.3	7
Georgia-Pacific	13	1222.0	22.0	−7	−66	1.8	4.9	5,414.0	160.0	8
Aluminum Co. of America[b]	10	1089.5	32.3	−16	−69	3.0	8.0	4,977.5	286.7	−3
Borden	34	1063.4	42.4	−4	25	4.0	3.1	4,415.2	159.9	−4
FMC	35	875.5	53.2	5	39	6.1	4.6	3,366.7	176.5	5
Martin Marietta	10	860.5	38.6	21	−11	4.5	6.1	3,294.1	200.1	26
Esmark[b]	13	849.9	27.4	12	72	3.2	2.1	3,132.3	99.6	15
Pfizer[b]	14	822.5	75.9	0	18	9.2	7.8	3,249.7	273.7	7
Northwest Industries[b,c]	6	821.7	79.8	16	58	9.7	7.1	3,121.6	252.9	29
Merck	16	760.4	92.1	7	−3	12.1	13.3	2,929.5	398.3	7
Kaiser Aluminum	13	717.5	−16.0	−14	def	def	5.2	3,225.5	132.9	−8
Borg-Warner	24	691.1	52.6	−2	40	7.6	5.4	2,761.2	172.1	3
NL Industries	19	671.6	92.0	31	106	13.7	8.7	2,463.8	310.2	36
General Tire & Rubber[b]	19	547.0	21.2	1	−22	3.9	5.0	2,175.2	70.3	17
National Distillers[b]	36	521.0	36.9	−5	−4	7.1	7.0	2,032.0	136.7	−1
Koppers[c]	30	513.4	14.1	1	25	2.7	2.2	2,018.6	51.6	5
Emhart	16	469.0	26.0	−3	160	5.5	2.1	1,747.0	75.0	−3
SCM[b]	13	466.0	11.0	−2	−5	2.4	2.4	1,916.2	51.2	1
Cabot[b]	31	399.7	25.6	3	−8	6.4	7.2	1,635.7	107.8	12
Big Three Industries	30	214.5	29.8	18	25	13.9	13.2	823.2	108.9	25
Vulcan Materials	37	197.0	18.0	−1	−12	9.1	10.3	783.3	78.2	4

a After-tax earnings as percentage of sales. b Excludes major nonrecurring earnings: U.S. Steel—$349 million in third-quarter 1981, $55.5 in first-quarter 1981, and $37.6 million in third-quarter 1980; Procter & Gamble—$75 million charge in third-quarter (calendar) 1980; Dart & Kraft—$65.8 million charge in fourth-quarter 1981; Aluminum Co. of America—$9.5 million in third-quarter 1981 and $27.3 million in 1980; Esmark—$388 million in fourth-quarter 1980; Pfizer—$52.4 million charge in first nine months 1981; Northwest Industries—$141

C&EN's survey, the fourth quarter showed much the same choppy pattern of financial results as in the third quarter. Although all were flying high in overall performance just a year ago, nine of these companies ended the fourth quarter with earnings up, seven with earnings down, and one unchanged from fourth-quarter 1980. Sales fell for three and rose for 14. Profit margins slipped for nine and rose for eight.

For all of 1981, the petroleum companies had quite a comedown from 1980. Although all had higher sales, 10 of the 17 had lower earnings, and 14 had lower profit margins. The three companies that still pushed up profit margins were Shell Oil, Union Oil, and Kerr-McGee.

Chemicals were a strong undertow for oil and gas firms' earnings, especially in the fourth quarter but also for the full year.

Among 25 nonpetroleum companies in C&EN's survey of diversified chemical producers, the fourth quarter was distinctly worse than the third quarter. Year-to-year data show earnings down for 13 and up for 12 in the fourth quarter and sales actually down for 10 and up for 15. Profit margins in these companies came out much like earnings in the fourth quarter—up for 13, down for 11, and unchanged for one. Perhaps it is noteworthy that 13 companies managed to increase profit margins in these circumstances. A rundown of these firms shows several in the wake of major reorganizations designed in large measure to beef up future profitability—Borden, Esmark, FMC, and NL Industries. Others are in the middle of a resurgence in corporate performance—Procter & Gamble, Pfizer, Northwest Industries, Borg-Warner, and Emhart.

Chemicals gave these companies plenty of problems in the fourth quarter, although there were exceptions. One company directly in the path of the economic storm was Georgia-Pacific, primarily a forest products firm. Chairman Robert E. Flowerree is in a better position to say than most when he comments, "High interest rates continued to depress residential construction, and the general economic recession had increasing impact on our paper and chemical businesses." However, he adds that the company's construction-related chemicals could come back quickly when conditions improve.

Another wrenching comment on the state of such durables markets comes from U.S. Steel. Chairman David M. Roderick notes, "Fourth-quarter 1981 steel product shipments were the lowest nonstrike quarter since the second quarter of 1946, and steel's operating rate was approximately 50% of capability, yet steel was profitable. These conditions are now expected to continue for the first half of 1982." This is bad news for industrial gases, lime, magnesium, and other chemicals going into steel as well as a poor indication for major steel markets, especially autos.

It is hard for large-volume chemicals to continue unscathed when basic industrial products such as steel and wood are in depressed conditions. For example, National Distillers' U.S.I. petrochemical division had a profit drop in the fourth quarter because of "weak market conditions and inade-

FULL-YEAR 1981			STOCK MARKET DATA							
Change from 1980	Profit margin[a]		Earnings per share		Stock price			Price-earnings ratio Jan. 29	Annual indicated dividend	Dividend yield, % of price
						Recent 12 months				
Earnings	1981	1980	Jan. 29	Recent 12 months	Jan. 29	High	Low			
9%	6.1%	6.1%	$1.99	$7.26	$62½	$ 69⅞	$51⅛	9	$3.20	5.1%
44	4.8	3.7	1.09	7.16	26⅛	35¼	23⅝	4	2.00	7.7
10	6.3	5.9	2.31	8.84	85¼	85¼	65⅛	10	4.20	4.9
8	4.1	4.1	1.40	7.56	52	54¾	42½	7	3.40	6.5
1	10.4	11.0	1.37	5.74	56⅛	65	48	10	3.00	5.3
−34	3.0	4.8	0.21	1.49	18¾	32⅜	17¼	13	1.20	6.4
−35	5.8	8.6	0.42	3.80	23	37½	22½	6	1.80	7.8
8	3.6	3.2	1.38	5.20	29⅞	30	25	6	2.05	6.9
25	5.2	4.4	1.46	4.88	25⅛	35¾	23⅛	5	1.60	6.4
6	6.1	7.2	1.08	5.39	31⅜	51⅛	28⅜	6	1.92	6.1
83	3.2	2.0	2.10	7.49	48⅛	55½	24¼	6	1.84	3.8
8	8.4	8.4	1.00	3.63	55½	56½	40	15	1.84	3.3
82	8.1	5.7	2.91	8.52	73⅛	76⅜	35¾	9	2.63	3.7
−4	13.6	15.2	1.24	5.36	84⅝	103	76¼	16	2.80	3.3
−56	4.1	7.1	−0.36	3.00	14¼	27½	14	5	1.40	9.8
36	6.2	4.7	1.22	4.00	27	28¾	18⅝	7	1.40	5.2
96	12.6	8.7	1.37	4.61	34¾	48⅝	29½	8	1.00	2.9
149	3.2	1.5	0.87	2.86	20	29½	18⅝	7	1.50	7.5
−3	6.7	6.9	1.08	3.97	23⅜	29¾	22	6	2.20	9.4
−4	2.6	2.8	0.43	1.58	15½	27¼	15¼	10	1.40	9.0
15	4.3	3.6	2.02	6.06	33¾	37½	26⅛	6	2.40	7.1
−12	2.7	3.1	1.10	4.99	21½	31⅝	20⅛	4	2.00	9.3
11	6.6	6.6	0.81	3.42	22⅛	35½	19⅞	6	0.92	4.2
26	13.2	13.1	0.70	2.57	25¼	38	22½	10	0.60	2.4
12	10.0	9.3	1.55	6.76	48½	56	40⅛	7	2.20	4.5

million in fourth-quarter 1981; General Tire—$4.4 million charge in first-quarter 1981; National Distillers—$30 million charge in 1980; SCM—$2.4 million charge in fourth quarter (calendar) 1981, $3.2 million charge in second-quarter (calendar) 1981, and $0.7 million charge in first-half (calendar) 1980; Cabot—$46.4 million in third-quarter (calendar) 1980. c Includes nonrecurring earnings.

quate pricing for polyethylene and vinyl acetate, two of its principal products."

Two other severe current problems for diversified chemical producers—the fertilizer market and natural gas prices—both had an impact on Borden. The company's chemical division operating (pretax) income declined 29% to $73.8 million because of a loss of $30 million in income from discontinued operations, largely phosphates and fertilizer, and about $60 million in increased natural gas costs. Borden currently is suing Texaco for $200 million for canceling a low-cost gas contract for about half its gas needs in chemicals.

If these production conditions weren't enough, a purely financial wrinkle has eaten away earnings at some heavily multinational companies—the stronger U.S. dollar. The foreign exchange factor handed Merck year-to-year earnings drops of 3% for the fourth quarter and 4% for all of 1981. Without this influence, earnings would have been up 16% in the quarter and 14% for the year. Merck's sales gain was reduced from 20% to 7% for the quarter and from 17% to 7% for the year. Similarly, at Pfizer, currency fluctuations slashed net income growth from 52% to 18% for the fourth quarter and from 43% to 8% for the year. Sales growth was whacked by about 8 percentage points in the quarter and 5 points for the year.

Besides these direct influences, currency shifts have other quieter effects. 3M chairman Lewis W. Lehr says that additional adverse effects that cannot be quantified with precision include higher costs in local currencies when overseas subsidiaries buy goods from a U.S. parent company.

Despite this backdrop of financial and market gloom, certain chemical operations still managed performance gains in the fourth quarter or the full year. For example, NL Industries more than tripled its operating (pretax) profit in its chemical operations, dominated by titanium dioxide, in the fourth quarter from a year ago. And NL notes that its 50%-owned titanium metals venture had a 67% earnings gain because of strong demand and pricing in titanium mill products and increased demand for oil field-related steel products.

Elsewhere, Kaiser Aluminum & Chemical reports that both its agricultural and industrial chemicals operations had profit pickups for full-year 1981. FMC says that sales and earnings increased strongly in the fourth quarter in pesticides from early ordering and food additives from market penetration overseas. And as before, Vulcan Materials had another strong quarter in its chemicals (influenced by shortage-plagued caustic soda) with both sales and pretax earnings gains of 8% from fourth-quarter 1980. For all of 1981, Vulcan's chemicals had a sales gain of 19% and earnings increase of 42% from 1980.

Nevertheless, Vulcan Materials president W. H. Blount calls the fourth quarter a slowdown and forecasts that it will carry over into the first quarter of 1982. Blount predicts lower first-quarter earnings for Vulcan and flat earnings for the year even with a significant economic upturn. □

Fewer recent Ph.D.s on science faculties

NSF study shows proportion of young faculty members in Ph.D.-granting departments dropped to 21% in 1980, continuing decade-old decline

The proportion of recent doctorates on the full-time faculties of science and engineering departments in Ph.D.-granting institutions has continued to decline over more than a decade. And that proportion is well below what department heads consider optimal.

A survey conducted by the National Science Foundation in the spring of 1980, and just published, documents that drop. Overall, the proportion of recent doctorates—those holding their degrees for seven years or less—had dropped to 21% in 1980.

The 1980 survey is the third in a series started by NSF in 1968. Besides monitoring the proportions of young faculty members in Ph.D.-granting departments, the 1968 survey also compared tenure status and research activities of recent and senior doctorates. A second survey followed in 1974 and included new information on faculty tenure status.

In scope, the 1980 survey was expanded to include new questions on faculty appointments and departures. Also, for the first time, the new edition includes data on age, sex, and race/ethnic makeup of faculties.

The 1980 survey included all of the 156 institutions that had awarded at least one science/engineering degree in 1975–76 and received at least $1.4 million in federal funds for R&D in 1977. The final weighted results represent a total of 39,760 full-time faculty members in 19 science/engineering fields.

Recent doctorates below percentage desirable

Field	Recent doctorates, % of total doctorate faculty	Recent doctorates desired by department heads, %[a]
Engineering	22%	30%
Chemical	24	29
Civil	25	29
Electrical	19	29
Mechanical	22	30
Physical sciences	15	25
Chemistry	16	27
Geology	20	28
Physics	11	22
Biological sciences	20	27
Biochemistry	14	25
Mathematical/ computer sciences	26	30
Social sciences	30	33
Psychology	27	34
All selected fields	22	30

[a] Median value of responses. Note: Data are from spring 1980. Source: National Science Foundation

The drop of recent doctorates to 21% of full-time faculties (including nondoctorates) in 1980 represented a sharp decrease from the 28% of 1974 and was considerably below the 39% of 1968. It also was well below the consensus of department heads that recent doctorates should make up 30% of all doctoral faculties.

Chemical engineering was the only discipline to buck the trend. Between 1974 and 1980, chemical engineering was the only field to show an increase, with a small gain to 23%. The fraction fell in 14 fields, the largest drop being in mathematics, where the share went from 35% to 22%.

Chemical engineering stood out in another feature as well. The fraction of full-time faculty with tenure rose in 12 of the 15 fields surveyed in both 1974 and 1980, with an average gain of about 5%. Only chemical engineering, at 73%, had a significantly lower tenure proportion in 1980 than in 1974. The greatest concentration of tenured faculty in 1980 was in physics, at 83%, and the lowest was in computer science, at 59%. In chemistry, 79% were tenured.

Among other findings:

- About 5% of full-time faculty members in 1978–79 changed employers or left the active labor force before the beginning of the next academic year. Voluntary resignations to accept other academic positions accounted for a third of the departures. Switches to nonacademic employment accounted for a fifth of the departures.
- Women had a larger level of representation among recent doctorates, 14%, than among senior doctorates, where they were 5%.
- About one in 12 faculty members belonged to race/ethnic minority groups, with a higher level of representation among recent doctorates. About two thirds of minority faculty were Asian or Pacific Islanders. The remaining minority faculty members were split about equally between blacks and Hispanics.

Copies of the report, "Young and Senior Science and Engineering Faculty, 1980" (NSF 81-319), are available free from the Division of Science Resources Studies, National Science Foundation, Washington, D.C. 20550. □

Less than a third of faculty members in engineering, physical sciences are under 40 years old

Field	All faculty	Age, %							
		Under 30	30–39	40–49	50–54	55–59	60–64	65–69	Over 70
Engineering	7236	6%	26%	34%	13%	12%	6%	2%	0
Chemical	1039	10	25	31	14	10	8	1	0
Civil	1886	4	29	34	12	12	6	2	0
Electrical	2313	6	26	35	14	11	6	2	0
Mechanical	1998	6	23	36	12	14	6	2	0
Physical sciences	8354	3	27	36	14	11	7	2	0
Chemistry	3380	4	30	34	12	10	7	3	0
Geology	1384	5	28	34	14	9	7	2	0
Physics	3590	2	25	38	15	12	6	2	0

Note: Data are from spring 1980. Source: National Science Foundation

NOTE

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Cover 1, p. 3, 6-8, 11-16,

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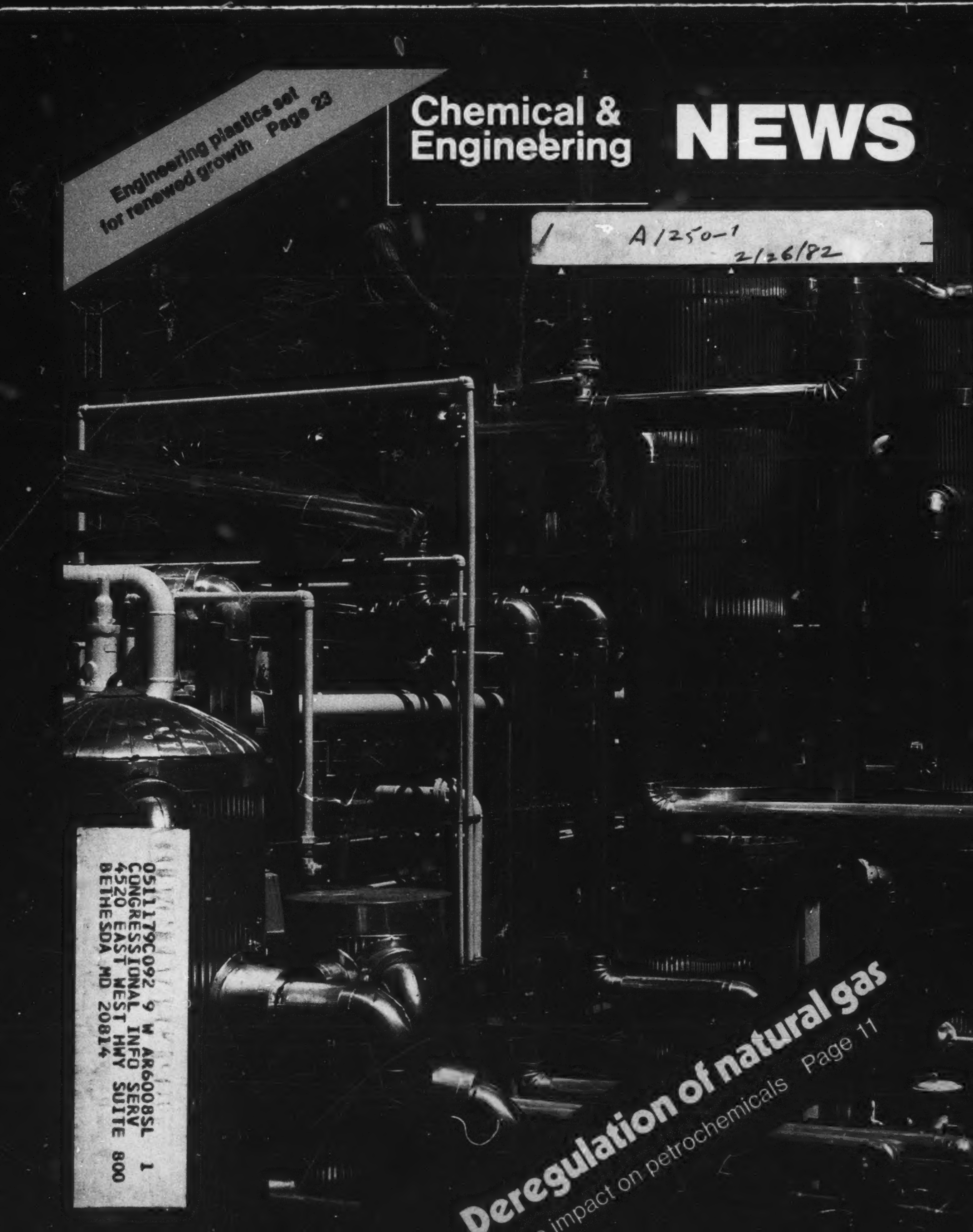

Engineering plastics set for renewed growth Page 23

Deregulation of natural gas

impact on petrochemicals Page 11

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Cover: Workman adjusts valve at Houston Natural Gas Corp.'s HNG Petrochemicals facility at Sonora, Tex., which recently was expanded to 60 million cu-ft-per-day capacity

4 Letters
5 Editor's Page

Concentrates
21 Business
27 Government
34 Science/Technology

The Departments
43 ACS News
48 People
48 Awards
64 Newscripts

News of the Week

- ***Plastics and fibers suffered*** *abysmal fourth-quarter 1981 to end a year in which total shipments moved up slightly but were still below 1979 levels.* ***Page 6***
- ***A high-protein strain of rice,*** *developed by USDA researchers, has more lysine than conventional strains.* ***Page 7***
- ***California academics will have to disclose*** *financial interests in firms from which they receive research funds, a state commission has proposed.* ***Page 7***
- ***ACS executive director Raymond P. Mariella*** *will retire when his five-year term ends Dec. 31.* ***Page 7***
- ***Chemical industry will recover*** *after first-quarter 1982, according to Commerce Department predictions.* ***Page 8***
- ***White House Science & Technology Council*** *members, who will counsel science advisor Keyworth, have been approved.* ***Page 8***

News Focus

- ***Prospects for natural gas decontrol*** *now appear slim, but concern over future supply is spurring the chemical industry to continue pushing for price decontrol.* ***Page 11***

Business

- ***Engineering plastics are doing better*** *than the overall plastics industry; although demand was down last year, it probably will pick up in second-half 1982.* ***Page 23***

International

- ***West German chemical industry*** *had sluggish year in 1981; although sales were up almost 10%, prices barely kept up with inflation and profitability was down.* ***Page 25***

Government

- ***Proposed budgets for regulatory agencies*** *that deal with chemical community are mostly up but still below funding levels for fiscal 1981.* ***Page 28***
- ***Review of Department of Energy*** *analyzes agency's successes and failures, argues for dismantling DOE.* ***Page 29***

Science Update

- ***Polymer chemistry theories*** *most successfully explain solution and melt properties, but controversies persist over crystallization, rubber elasticity, other areas.* ***Page 36***

Education

- ***New programs adding a strong measure of engineering*** *to traditional undergraduate chemistry have been set up at Michigan Tech and at Rensselaer.* ***Page 38***

Books

- ***"Seeds of Discovery,"*** *by W. I. B. Beveridge, depicts the crucial, but often unacknowledged, role that chance has played in the making of scientific discovery.* ***Page 40***

PLASTICS, FIBERS FINISH YEAR IN TROUBLE

Everyone expected 1981 to be a time of turnaround for plastics and fibers, the two main branches of commercial polymers. But the year was actually a time of turndown. And it doesn't look like things will get better soon. Business conditions during the winter can be called poor and poorer.

Overall, 1981 was not good for plastics and was especially poor for fibers. The final three months were markedly bad for both as fresh data attest.

For all of 1981, plastics shipments increased just 3.2% from 1980 to 27.9 billion lb, according to data published by the Committee on Resin Statistics of the Society of the Plastics Industry. This followed a drop in 1980 of 9% from 1979's 29.8 billion lb. These figures exclude phenolic resins. The SPI changed its reporting base for phenolics last year, putting them on a gross-weight, rather than a dry-weight, basis as they had been in the past. Thus, the figures for phenolics between 1980 and 1981 are not comparable and if they are included with the other plastics, it throws those figures off. The data are gathered for SPI by the New York City accounting firm Ernst & Whinney.

Shipments of thermoset resins, excluding phenolics, increased just 1.9% in 1981 to 2.62 billion lb. Shipments in 1980 had been down 15% from 1979 levels.

The five major thermoplastics—low-density and high-density polyethylene, polypropylene, polystyrene, and polyvinyl chloride—performed better last year than did thermosets, but still they managed only a 3.2% increase from the year before. Shipments of the five major thermoplastics totaled 25.32 billion lb in 1981 compared with 24.50 billion lb in 1980. Shipments in 1980 were 8.4% below 1979 shipments figures of 29.77 billion lb.

Fiber shipments in 1981 dipped slightly below 1980 levels. For man-made fibers, shipments last year amounted to 8.62 billion lb, a drop of 1.4% from 1980. Shipments in 1980 had been down 5.7% from 1979's 9.27 billion lb.

The cellulosics—rayon and acetate—were the worst performers in 1981. Total cellulosic shipments reached almost 718 million lb, falling 4.7% from 1980. Shipments in 1980 had been 12.6% below 1979.

Noncellulosic shipments dropped 1.1% to 7.90 billion lb in 1981; shipments the previous year had been 5.0% below 1979 levels.

However, if the full year was bad, the final quarter of 1981 was abysmal for polymers. Shipments of plastics dropped 11.4% from fourth-quarter 1980 to 6.48 billion lb. And man-made fiber shipments dropped even more, 17.1% to 1.94 billion lb.

Of the plastics, thermosets, again excluding phenolics, were worse off. Thermoset shipments in the fourth quarter dropped 16.0% from a year earlier to about 556 million lb.

The five major thermoplastics, however, also did not have things going their way. Shipments for these big-volume products dropped 10.9% in the quarter to 5.92 billion lb. The biggest loser of the thermoplastics was polyvinyl chloride, shipments of which fell 20.2% to 1.16 billion lb in the quarter.

In fibers, unlike the year as a whole, it was the noncellulosics that had the largest drop in the last three months of 1981. The cellulosics dropped 9.4% to 161 million lb. Rayon shipments held almost flat at about 108 million lb in the quarter, just 1.6% below shipments in fourth-quarter 1980. In the cellulosics, it was acetate that took a dive in the fourth quarter. Acetate shipments dropped 22.1% to 53.1 million lb.

However, noncellulosic shipments, led by nylon, fell 17.8% in the fourth quarter to 1.78 billion lb. Nylon shipments in the fourth quarter plummeted 35.5% to 446 million lb. This drop was largely because of poor construction markets affecting nylon going into carpets. Nylon carpet filament shipments in the fourth quarter dropped to 123 million lb. And nylon staple fell 44.9% to about 126 million lb.

Unfortunately, the worst is not

Polymer shipments edged up slightly in 1981

				% change	
Shipments, millions of lb	1981	1980	1979	1980-81	1979-80
PLASTICS					
Thermosets[a]	**2,624.6**	**2,576.4**	**3,030.6**	**1.9%**	**−15.0%**
Epoxy	332.1	318.8	332.0	4.2	−4.0
Polyester	976.0	944.4	1,151.6	3.3	−18.0
Urea	1,139.9	1,147.3	1,355 3	−0.6	−15.3
Melamine	176.6	165.9	191.8	6.4	−13.5
Phenolic[b]	2,386.7	1,516.6	1,731.9	nc	−12.4
Thermoplastics	**25,324.4**	**24,500.0**	**26,737.4**	**3.4**	**−8.4**
Low-density polyethylene	7,516.4	7,467.5	7,814.8	0.7	−4.4
High-density polyethylene	4,682.8	4,393.6	4,893.2	6.6	−10.2
Polypropylene	3,891.0	3,714.5	3,894.3	4.8	−4.6
Polyvinyl chloride	5,631.7	5,407.2	6,137.9	4.2	−11.9
Polystyrene	3,602.5	3,518.0	3,997.2	2.4	−12.0
TOTAL PLASTICS[a]	**27,949.0**	**27,076.4**	**29,768.0**	**3.2%**	**−9.0%**
FIBERS					
Cellulosic	**717.8**	**753.6**	**862.7**	**−4.7**	**−12.6**
Rayon	456.7	451.7	542.5	1.1	−16.7
Acetate	261.1	301.9	320.2	−13.5	−5.7
Noncellulosic	**7,898.2**	**7,988.1**	**8,406.6**	**−1.1**	**−5.0**
Polyester	4,168.8	4,035.9	4,146.1	3.3	−2.8
Nylon	2,254.8	2,430.0	2,722.2	−7.2	−10.7
Acrylic	694.5	771.1	770.2	−9.9	0.1
Olefin	780.1	751.1	768.1	3.9	−2.2
TOTAL FIBERS	**8,616.0**	**8,741.7**	**9,269.3**	**−1.4%**	**−5.7%**
TOTAL POLYMERS[a]	**36,565.0**	**35,818.1**	**39,037.3**	**2.1%**	**−8.2%**

a Totals excluding phenolic resins. b 1981 shipments are on a gross weight basis, previous years are on a dry weight basis. nc = no change.

over for producers of fibers and of plastics. Observers in both industries say that January has not shown any signs of increased momentum. Plastics producers seem especially pessimistic as demand for the leading thermoplastics continues to fall. And for the full year, most are not expecting any great increase over 1981. □

High-protein rice developed at USDA

Using plant tissue culture techniques, researchers at the Department of Agriculture's Agricultural Research Service have developed a new strain of rice with substantially more of the amino acid lysine than conventional rice strains have. Lysine is the essential amino acid that is in the shortest supply in rice and many other grains; thus, it limits the nutritional value of rice. The new rice produces about 10% more protein—and protein that contains 5 to 7% more lysine—than do other rice strains.

The work is being done by Gideon Schaeffer and associates in USDA's Cell Culture and Nitrogen Fixation Laboratory at Beltsville, Md. So far, they have grown the new strain through five generations in greenhouses and one season in field tests at Stuttgart, Ark. The next step will be to try to crossbreed this strain with others that are particularly well adapted to U.S. growing conditions. This will be done using conventional plant breeding techniques.

Schaeffer examines high-lysine rice

The high-lysine rice was developed by a technique known as anther culture, in which pollen grains (produced by the anthers of rice flowers) are cloned, and mutants with a desired trait are selected out chemically. These desirable mutants then are treated with plant hormones and grown into small plantlets in test tubes, transferred to pots of soil, and grown to maturity. Their seeds are used to produce the next generation of plants.

Pollen is used as the starting material because it is composed of haploid cells that have single, rather than paired, chromosomes. Thus, whatever genes are present in these cells will be expressed in the plant. This greatly reduces the amount of crossbreeding needed for desirable traits to be expressed and means new strains can be developed much faster and at lower cost.

High-lysine-producing clones are selected by growing the cells in a medium containing aminoethylcysteine, a substance that inhibits the enzyme aspartokinase, which directs the final step in the biosynthesis of lysine. Mutants that can grow in this medium somehow have managed to overcome this restriction and still make lysine. Exactly how they do this is not known, but they may have a second mechanism for making lysine that does not involve aspartokinase. Alternatively, they may produce a modified enzyme that is not sensitive to inhibition. Whatever their method, such mutants produce more lysine under normal growing conditions than do other rice plants. □

California academics face disclosure rules

Regulations proposed recently by the California Fair Political Practices Commission (FPPC) will bring research scientists at the University of California under much the same conflict-of-interest rules that govern other state officials.

Under the proposed regulations, any university scientist receiving research funds from a private firm must declare whether he or she has a financial interest in that firm and the magnitude of that interest. According to FPPC's chairman Tom K. Houston, a financial interest includes income or gifts from or stockholdings in a company. It also includes holding a management position in a company or serving on its board of directors.

"If a conflict of interest is revealed," Houston says, "the university will have to set up an independent panel to undertake a substantive review of the research project to decide if it can go forward and under what circumstances." Houston says that who will serve on such panels and how they will function is being left up to the university.

The regulations are scheduled to be adopted formally by the commission at a meeting on March 1. Houston says that he does not expect any substantive changes as a result of public comment.

Houston emphasizes that University of California scientists are not being singled out for special treatment. "All state employees who have decision-making authority currently are required to disclose all interests in businesses that they may affect by their decisions," he says. University scientists have been the only exception, Houston points out, because of concerns about academic freedom.

"That concern still holds," he says. However, according to Houston, several scientists testified at FPPC hear-

Mariella to retire as ACS executive director

Raymond P. Mariella has announced that he will retire as executive director of the American Chemical Society when his five-year term expires Dec. 31, 1982. Mariella has agreed to assist the chairman of the ACS Board in a consulting capacity in 1983 and 1984. Clayton Callis, currently board chairman, says that during Mariella's administration the financial condition of the society has been improved substantially and ACS membership has grown steadily to a record level of almost 123,000 members worldwide. In addition, a number of services to the membership have been strengthened and augmented. Mariella has been particularly active in recent months in promoting improved relationships with chemical and other professional societies around the world. He also has been instrumental in providing information about chemists and chemistry to government officials and their staffs in order to assist them in understanding the technical issues with which they are confronted.

ings that they were reluctant at present to share data and resources with certain other scientists whom they suspected of having ties to private industry and using the information for private gain. "They said that nondisclosure actually was inhibiting the flow of information," he says.

The FPPC action is the result of the increasingly tangled relationships between academics and the private sector, particularly in genetic engineering (C&EN, Oct. 12, 1981, page 39). According to a representative of the University of California, in December 1981 the university put out guidelines (which had been under development for more than a year) with essentially the same requirements as the FPPC rules. ☐

Chemicals to recover in 1982, government says

In a winter that has brought an increasingly sober view of 1982 in the U.S. chemical industry, the government is trying to sound a note of cheer. It says there will be recovery later this year and that chemicals will do better than average.

Bristling with statistics, the Commerce Department has issued its annual "U.S. Industrial Outlook" (available for $10 from the Government Printing Office). The 446-page tome will not reward connoisseurs of style and it cries for a summary. But in its deliberate way, the volume sides distinctly with the optimists about business prospects.

Commerce admits that the recession inherited from late 1981 will last through the first three months of 1982. But that's it, the government contends. After the winter, a slow recovery is in store with "some reduction" in the recent depressingly high inflation and interest rates.

Getting immediately to the numbers, Commerce pins down everything from gross national product to shipments of lawn and garden equipment to a decimal point. For the big statistic, the new volume puts the real-dollar increase in gross national product this year at 1.4%, down from 2.1% in 1981. That's pretty slow growth but at least is not another economic decline.

In chemicals, Commerce foresees faster real-dollar shipments growth than for either GNP or the nondurables family of manufacturing industries, in which chemicals rank just behind food as the second largest. For the broad category of chemicals and allied products, Commerce puts deflated shipments growth at 2.4% in 1982, up from 2.0% in 1981. Combined with the government estimate of 9.5% inflation in 1982, such growth would give chemicals a shot at $200 billion in sales, up roughly 12%.

In other sections, the Commerce outlook volume examines a host of smaller industry subcategories, ranking them for both current and long-term growth. Certain chemical and related groups make the higher growing lists for both 1982 and the long-term. But in general, Commerce says that these chemical groups will drop position in 1982 and have slowed greatly from the mid-1970s. ☐

Most chemical, related fields drop in growth ranking in '82

Shipments[a]	1980–81 % Change	1980–81 Rank	1981–82 % Change	1981–82 Rank	Industry code
Plastic products	11.0%	7	6.6%	28	3079
Biologicals	10.7	8	7.5	19	2831
Synthetic rubber	10.0	9	6.8	24	2822
Medicinals and botanicals	7.6	14	7.5	19	2833
Plastics	6.3	23	6.7	26	2821
Inorganic pigments	5.2	31	1.6	117	2816
Surfactants	3.8	39	3.8	58	2843
Photographic equipment	3.2	52	4.5	47	3861
Soaps and detergents	2.3	63	2.3	103	2841
Industrial organic chemicals	2.2	65	2.1	106	2819
Pharmaceuticals	1.8	74	1.8	113	2834
Pesticides	1.3	83	1.2	128	2879
Paint	1.0	89	1.9	112	2851
Industrial organic chemicals	0.8	95	0.4	143	2860
Nitrogenous fertilizer	0.8	95	0.8	137	2873
Cosmetics	0.6	99	1.4	123	2844
Phosphate fertilizer	0.0	108	2.7	91	2874
Chlorine-caustic	−1.1	117	−1.3	152	2812
Industrial gases	−2.9	128	1.3	125	2813

a Rankings are for industry subgroups in 168 categories. Source: Commerce Department

White House science advisory panel approved

The men around President Reagan finally have gotten around to approving members of the White House Science & Technology Council nominated by science adviser George A. Keyworth late last year. It is a 13-man group, chaired by Solomon J. Buchsbaum, vice president of Bell Telephone Laboratories. Vice chairman of the group is Edward Frieman, vice president of Science Applications Inc. of La Jolla, Calif. Unlike the former President's Science Advisory Committee, the group will counsel Keyworth, not the President.

On the face of things, the science and technology council seems heavily oriented toward national defense. Members include Harold M. Agnew, formerly director of Los Alamos National Laboratory and now president of General Atomic Co.; George A. Cowan, a Los Alamos physicist; Edward E. David, president of Exxon Research & Engineering who made his name in naval acoustics; David Packard, chairman of Hewlett-Packard Co.; and Edward Teller, founder of Livermore National Laboratory, so-called father of the hydrogen bomb, and now a senior research fellow at Stanford University's Hoover Institution.

Rounding out the council are John Bardeen, emeritus professor of electrical engineering and physics, University of Illinois; D. Allan Bromley, professor of physics at Yale; Paul E. Gray, president of Massachusetts Institute of Technology; Robert O. Hunter Jr., president of Western Research Co.; Arthur K. Kerman, director of the center for theoretical physics at MIT; and Donald S. Frederickson, a physician, formerly director of the National Institutes of Health and now a fellow at the National Academy of Sciences. Frederickson is the only life scientist on the panel. No chemist, biologist, or social scientist was appointed.

The council will meet for the first time next month. Keyworth is deciding whether to open the meetings to the public and the first agenda is being drawn up. ☐

Outlook dims for decontrol of natural gas

Fear of future supply shortages and inequities under the Natural Gas Policy Act, however, keep chemical industry fighting for total price decontrol

Earl V. Anderson
C&EN, New York

A lot of people in the chemical industry are watching the nation's capital to see if, by some miracle, they will get some action on decontrol of natural gas prices.

They have been doing that for quite a while. And there was a time when it appeared as if they would get their wish—to get out from under the shackles of the Natural Gas Policy Act of 1978 (NGPA) and switch to total, phased decontrol of natural gas prices.

True, it would cost chemical companies more for their gas. But they are more concerned about an adequate and secure long-term supply of gas at "competitive" prices. They don't see that under NGPA.

Prospects for natural gas decontrol rose last year after President Reagan decontrolled crude oil prices. After all, deregulation was the name of the new Administration's game, and natural gas stood out as a major decontrol target.

But natural gas decontrol is a much tougher nut to crack than oil. President Reagan was able to use an executive order to decontrol oil prices. Natural gas decontrol will require Congressional action.

Still, prospects looked good until recently. Several bills introduced last year were designed to remove wellhead price controls of natural gas. The most promising was legislation introduced by Rep. Phil Gramm (D.-Tex.), which decontrol advocates felt comfortable with. Several times last year, the Administration seemed on the verge of sending up to the Hill its own bill to phase out natural gas price decontrols. It never happened.

Even this year, prospects looked good for natural gas decontrol. Word around Washington was that President Reagan was again ready to submit his own decontrol proposal to Congress. Rep. Gramm reintroduced his own bill and, on the Senate side, Sen. J. Bennett Johnston (D.-La.) introduced a bill similar to the Gramm bill. With legislative proposals in both houses, and an Administration receptive to deregulation, things were beginning to look up.

But that fickle barometer Washington watchers use to gauge legislative prospects such as natural gas decontrol has dropped from optimistic to pessimistic. Chances of passing a gas decontrol bill this year now appear slim. "It's becoming discouraging," says Patrick H. McNamara, Dow Chemical's government relations manager and cochairman

Pipeline network at Houston Pipe Line's Bammel Field storage reservoir, Houston

Natural gas and natural gas liquids are lifeblood of the chemical industry

	1980 consumption, trillion Btu			
	Petro-chemicals	%	Total chemicals & allied products	%
Fuels	2276	100.0%	3636	100.0%
Natural gas	1276	56.1	1506	41.4
Distillate & resid	203	8.9	298	8.2
Coal	156	6.8	286	7.3
Purchased electricity	641	28.2	1566	43.1
Feedstocks	2540	100.0	2540	100.0
Natural gas	588	23.2	588	23.2
Ethane	456	17.9	456	17.9
Propane	442	17.4	442	17.4
Butane	147	5.8	147	5.8
Isobutane	20	0.8	20	0.8
Heavy liquids	887	34.9	887	34.9

Source: Arthur D. Little Inc.

of the Petrochemical Energy Group (PEG).

Apparently, natural gas decontrol has run out of time. Those with political savvy say that if no action is taken by the end of this month, natural gas decontrol is dead, at least for this year. Congress will be overloaded with many issues that are considered more important, not the least of which are the budget and the economy.

With many Congressmen up for re-election later this year, they are looking forward anxiously to early adjournment. And many of them don't relish the idea of facing the voters with talk of supporting a bill that could raise their already rising gas bills.

Opposition groups, such as the American Gas Association and several consumer-citizen groups, are fanning that issue. A cornerstone argument is that decontrolling natural gas prices will serve only to fuel inflation. Says Rep. Dan Glickman (D.-Kan.), "to [decontrol gas] would be a slap in the face to the people... we are working to protect from inflation."

Time, the economy, and the upcoming elections seem to be working against natural gas decontrol this year. And faced with a full, short calendar, legislators don't relish the prospect of dealing with a complicated issue that is complicated further by the possibility of a windfall profits tax.

The smart money says that Congress won't pass a decontrol measure without a windfall profits tax. Yet, President Reagan is already on the record—written record—that he will veto "with pleasure" any bill that contained a windfall profits tax.

Contrary to what "the smart money" says, many decontrol advocates don't believe that a windfall profits tax is inevitable. Lobbyists have been doing a lot of "educating" on Capitol Hill, and many Congressmen who felt that a windfall profits tax wouldn't cost the public a cent now understand that it is really a tax on the consumer—hidden, no doubt, but there nonetheless.

A tax on natural gas probably would be an excise tax rather than an income tax. Such a tax would tend to crimp production. The result, for consumers, would be less gas, but they would pay more for it.

Faced with a staggering federal deficit, a windfall profits tax also looks appealing because it could pour much-needed dollars into the Treasury. But according to Chase Econometrics, a natural gas excise tax that would generate $15 billion in 1985 tax revenues would bring a net improvement of only $1 billion because of various offsets.

Natural gas prices will vary widely among pipeline firms

Pipeline company	Prices in $ 1981 per million Btu[a] 1985	1990
Algonquin Gas Transmission	$5.22	$8.54
Cities Service	3.05	5.31
Colorado Interstate	3.36	5.61
Columbia Gas Transmission	4.93	7.26
Consolidated Gas Supply	5.05	7.68
El Paso Natural Gas	3.40	5.21
Florida Gas Transmission	4.13	7.02
Michigan Wisconsin	4.56	6.85
Midwestern Gas Transmission	5.57	7.70
Mississippi River Transmission	5.59	7.46
Natural Gas Pipeline	4.26	6.33
Northern Natural Gas	4.15	6.44
Northwest Pipeline Corp.	4.50	5.41
Pacific Gas Transmission	5.75	7.41
Panhandle Eastern	4.00	5.98
Southern Natural Gas	4.92	7.17
Tennessee Gas Pipeline	4.21	6.52
Texas Eastern Transmission	4.06	7.73
Texas Gas Transmission	4.80	7.55
Transcontinental	4.00	6.05
Transwestern	4.98	6.46
Trunkline Gas	4.47	6.10
United Gas	5.36	7.35

[a] Average cost to pipeline companies, depending upon mix of regulated, deregulated, and substitute gas supplies. Source: Foster Associates

Meanwhile, as gas output and consumption went down because of the tax, economic growth also would go down. Chase estimates that the $15 billion excise tax would reduce 1985 gross national product by $30 billion. That's a lot to pay for a $1 billion reduction in the deficit.

Obviously, the political battle over natural gas decontrol won't be easy, especially with the dispute over a windfall profits tax complicating the issue.

It already may be too late to do battle, at least this year. If so, natural gas will continue under NGPA, with partial decontrol coming in January 1985. Now there are even indications that an extension of phased-decontrol all the way to 1988 will be pushed.

To the chemical industry, that would be unthinkable. Basically, what the chemical industry wants is phased decontrol of all natural gas prices by a single date, preferably by 1985. Different categories of gas under NGPA should not have different target dates, the industry argues.

But unless decontrol legislation is enacted this year, achieving total decontrol by 1985 will be difficult. There just wouldn't be enough time to phase it in.

Despite the obstacles, the industry isn't giving up the fight. To chemical companies, an adequate and reliable supply of natural gas at a competitive price is paramount. They know that decontrolling natural gas prices is going to increase their feedstock and fuel costs, but these costs are going up anyway, even under NGPA, and the primary concern is supply.

In this, the industry is virtually united. PEG and the Chemical Manufacturers Association (CMA) are handling the political effort in Washington. All but a very few companies whose particular oxen aren't being gored by NGPA are solidly behind this effort.

Little wonder. Natural gas is the lifeblood of the industry. The chemical industry accounts for more than 10% of total U.S. natural gas consumption—about 3% for feedstock and 7% for process fuel and other uses. For feedstock, it also consumes large amounts of natural gas liquids (NGLs) extracted from gas streams. NGLs are certain to be affected by what happens—or doesn't happen—to natural gas decontrol.

To PEG, CMA, and its chemical company members, the villain is NGPA. They feel that the wellhead price controls established under NGPA are causing serious problems not only for the industry, but for the entire nation. These problems likely will get worse.

NGPA was supposed to decontrol natural gas prices without disrupting the market. So far, it hasn't come close to succeeding. The market already is disrupted. There are 26 categories of natural gas spelled out in NGPA. Prices vary widely from pipeline to pipeline, often within the same geographical region. Some pipelines have gas running out of their ears. Others are short.

As Jan. 1, 1985, approaches and substantial amounts of gas become decontrolled under NGPA, the disruption could become more severe.

NGPA opponents are adept at compiling long lists of complaints about the law. They don't like its

Natural gas liquids will be affected by decontrol

1985 demand, thousands of barrels per day	1980	Gas decontrol options		
		Current decontrol act	Controls phased out by 1988	Complete decontrol by 1985
Ethane				
Chemicals	376	249	405	407
Total	465	284	528	460
Gas plant production	408	279	455	455
Propane				
Chemicals	244	262	313	313
Total	802	851	954	934
Gas plant production	483	321	433	433
Butanes				
Chemicals	87	118	117	117
Total	398	402	413	413
Gas plant production	313	259	263	263

Source: Resource Planning Consultants

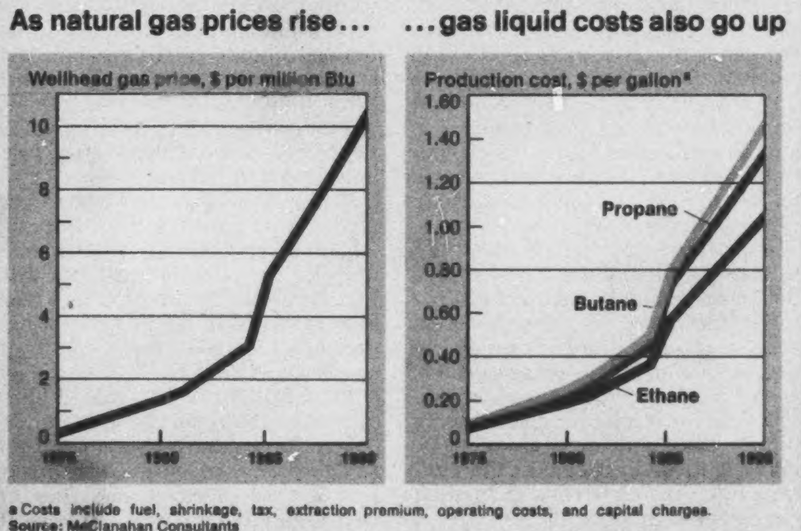
phased decontrol structure. They don't like its incremental pricing provisions. But the act's biggest shortcoming is that some of its basic premises have been proved wrong.

The most serious, perhaps, is that the bill's designers, with an eye toward parity between oil and gas prices by 1985, estimated that crude oil would be selling for about $15 per barrel (in 1978 dollars) on the world market in 1985. They didn't foresee the second oil crisis of 1979–80. As a result of that crisis and the runup in prices, refiner acquisition costs for crude oil last year averaged about $37 per bbl, or about $29 in 1978 dollars.

Although NGPA provides for some decontrol, it is as much a control bill as it is a decontrol bill. It slaps price controls on most natural gas and stipulates monthly inflation and escalation adjustments. It controls access to some natural gas, such as offshore gas, and even controls the terms under which some gas is purchased.

Under the old Natural Gas Act, interstate natural gas price was regulated. Intrastate gas price wasn't. But NGPA extends price controls to intrastate gas now and gives interstate pipelines access to intrastate gas reserves. Taken separately, each of these controls creates problems for producers, pipelines, and consumers alike. Taken together, these problems become even more difficult and complex.

Problems related to price controls are probably the most serious of the lot, at least as far as the chemical industry is concerned. So far, only one small category of natural gas has been deregulated by NGPA. That's the so-called "107" gas (after the section number in NGPA that controls it.). Known universally as "high-cost gas," most of it flows from deep wells (15,000 feet or deeper). Section 107 gas now accounts for only 4% of natural gas production, but some pipelines are paying as much as $9.00 to $11 per thousand cu ft to get it. In the process, a few producers are getting very rich. Not surprisingly, these producers like NGPA just as it is.


As natural gas prices rise...
...gas liquid costs also go up

a Costs include fuel, shrinkage, tax, extraction premium, operating costs, and capital charges.
Source: McClanahan Consultants

On Jan. 1, 1985, NGPA decontrols the prices of some additional categories of gas. The largest slug will be "new" gas (section 102). This gas now represents about 20% of natural gas output, but it will swell to about 42 to 45% by 1990. Some of the other gas that will be decontrolled in 1985 is old intrastate gas (section 105). Old interstate gas (section 104), however, remains under control.

As far as the chemical industry is concerned, the key word in all of this is "some." Contrary to what many believe, not all gas prices come out from under controls in 1985. A lot—a whole lot—of gas will remain regulated permanently after 1985. And even some that is deregulated can be shoved back under price controls until 1986 by Presidential action.

Even the experts can't agree on just how much gas will remain under price controls after 1985. The guessing falls between 40 and 60%. Whatever the figure, it is substantial. And it is this aspect of NGPA—that only some controls on some gas will disappear in 1985—that troubles the chemical industry most. For gas-dependent chemical companies, the problem is not the gas that comes out from under price controls, it is the gas that remains controlled.

This one-shoe-off, one-shoe-on approach is creating a problem that everyone refers to as the "cushion" problem. The cushion problem has altered the competitive positions of interstate and intrastate pipeline companies. Where once the intrastate companies were in the driver's seat, it is now the interstate pipelines that have the upper hand.

Here's how the cushion works. Company A has a large supply of low-priced gas that is controlled by NGPA (its cushion). Company B has very little of that gas. As a result Company A can bid much more for its new supplies of decontrolled gas, such as 107 deep gas, than can Company B. It can do this because it can average, or "roll in," the high price

A lot of natural gas will remain regulated permanently after 1985

Section	Description	Decontrolled
102	New natural gas	
	Certain new onshore wells	Jan. 1, 1985
	New onshore reservoirs	Jan. 1, 1985
	New offshore leases	Jan. 1, 1985
	New reservoirs on old offshore leases	No
103	New onshore production wells	
	Deeper than 5000 ft	Jan. 1, 1985
	Shallower than 5000 ft	Jan. 1, 1987
104	Old interstate gas	
	Post-1974	No
	1973–74	No
	Replacement contract or recompletion gas	No
	Flowing gas	No
	Certain Permian Basin gas	No
	Certain Rocky Mountain gas	No
	Certain Appalachian gas	No
	Minimum-rate gas	No
105	Old intrastate gas	
	Contract price less than $2.078 on Nov. 9, 1978	Jan. 1, 1985
	Contract price more than $2.078 on Nov. 9, 1978	Jan. 1, 1985
106	Gas sold under "rollover" contracts	
	Interstate	No
	Intrastate	Jan. 1, 1985
107	High-cost gas	
	Wells 1500 ft or deeper	Nov. 1, 1979
	Geopressured brine, coal seams, and Devonian shale	Nov. 1, 1979
	Tight sands	No
	Qualified production enhancement	No
108	Stripper wells	No
109	Other categories (including Prudhoe Bay)	No

it paid for the new gas with the much lower price it paid for the old gas and still sell to its customers at or below the cost of alternative fuels. NGPA's basic premise about the 1985 target price of oil made sure of that.

Company A also can outmarket other companies who are not fortunate enough to have the cushion. Companies that enjoy cushions can bid up the price of decontrolled, 107 gas above what the industry calls market-clearing levels and still compete effectively in the market.

For most chemical companies, the important question is who has the cushion? Unfortunately for them, the answer is the interstate pipeline companies.

Remember that much of the petrochemical industry is located on the Gulf Coast, in Texas and Louisiana. That is intrastate market territory. Many plants in the area already are starting to feel the squeeze caused by the cushion problem.

Interstate pipelines will have a large volume of old (section 104) gas remaining under price controls until their reservoirs are depleted. They can afford to pay the much higher prices for decontrolled, 107 gas. That's exactly what they are doing now.

Intrastate pipelines, meanwhile, will be forced to meet those wellhead prices for new gas if they want to replenish their supplies. But intrastate lines don't have that big cushion of 104 gas. Its old (105) gas becomes decontrolled in 1985.

What this means is that intrastate pipelines will be paying, on average, more for their purchased gas than their interstate counterparts. According to the Energy Information Administration (EIA), old intrastate gas will be going for $3.29 per thousand cu ft at the wellhead in 1985. Old interstate gas will be a substantially lower $1.01. That's a hefty cushion in the bidding for new gas.

It's also bad news for chemical companies that must rely on intrastate pipelines for their gas supply. Although all companies on intrastate lines will be hurt, those that use natural gas as a feedstock, such as ammonia and methanol producers, will feel the impact even more.

Monsanto, for instance, is facing a serious problem at its Luling, La., ammonia plant precisely because of the 104 cushion situation. Its present gas contract expires at the end of 1983. After that, if it is able to buy any gas at all, it will be only at uncontrolled prices. That could mean a price increase of $2.00 to $3.00 per thousand cu ft, which translates into an $80 to $120 per ton difference in the cost of ammonia.

For Monsanto, that's a tough pill to swallow when ammonia is expected to be selling for about $420 per ton in 1985. And it's too much of an edge to give to ammonia producers that are not on an intrastate pipeline.

To Charles P. Fullerton, Monsanto's director of planning and energy policy, the solution is simple. Remove controls on 104 gas at the same time that controls are lifted on other gas categories.

Other ammonia producers tied in to intrastate pipelines no doubt agree. They account for 60% of U.S. ammonia output. The 40% on interstate lines may or may not agree, depending upon where they are located. That is because not only is there a wide disparity between interstate and intrastate prices, but there are wide-ranging differences even among interstate lines. In a study that it made for PEG, Foster Associates estimates that in 1985 the average, rolled-in price of gas could vary as much as 90% among interstate pipelines. This means that even in the same region, one chemical company could be paying much more for its gas than another. It depends upon who the supplier is.

As concerned as petrochemical companies are about natural gas, they are just as concerned about natural gas liquids. NGLs are a big part of the industry's feedstock picture. What happens to natural gas—its degree of regulation, its supply, and its price—will influence the price and supply of NGLs.

Natural gas processors who extract NGLs from gas streams are as uncertain about their future as the natural gas industry is about its own. For them, the big questions are what happens to NGL as the price of natural gas increases, and should the processor extract NGL from the gas or leave it in for its Btu value? These questions are important ones for the petrochemical industry, too.

The processor is between a rock and a hard place. It sees its costs rising and knows it must raise its NGL prices to make a profit. But it also knows that NGL is highly price-competitive and that there is a limit to what the market will bear.

NGL's track record over the past few years bears this out. During 1979 and 1980, ethylene producers that had the flexibility to use either light feedstock (NGL) or heavy feedstocks such as naphtha or gas oil found little to choose from between the two. On a per-pound of ethylene basis, both were competitive.

Last year, NGL prices started dropping and light feedstocks captured a competitive edge. The market responded. The share of ethylene output from ethane and propane went up 4% last year. About half of the heavy liquids crackers in the country are using ethane or propane.

That's fine for those liquid-based olefin plants that have the flexibility to switch to light feeds when the price is right. And recently the price has been very right. Ethane has been selling for 20 cents per gal and less.

But don't expect to see any new ethane-only cracking units soon just because today's price is right. That price probably won't last long. Upward pressures already are becoming apparent.

More important, says Dave McClanahan of the consulting firm McClanahan Associates, it has become increasingly difficult to get ethane in large enough volumes to justify new ethane crackers. Small, economic cryogenic extraction plants now make it possible to extract ethane even from small gas packages. But ethane pipelines, says McClanahan, though extensive, are not universal. As a result, not all of the little extraction plants capable of recovering ethane are or will actually do it.

The problem as he sees it is one of limited ethane demand. There has been very little ethane- or ethane/propane-based ethylene capacity installed in the past few years. The buildup in ethane-based capacity has come from revamping heavy liquids units.

Not until after the mid-1980s does he see more ethane or propane crackers being built in the U.S. Until then, because operating rates are low, there won't be much locked-in demand at plants that can use no other feedstock.

This, McClanahan says, means that ethane prices will be in competition with propane and subject to downward pressures because of a weak crude oil market during the early 1980s.

Carlton R. Jones, president of Resource Planning Consultants, agrees that NGL prices will be influenced by crude prices. But he also thinks that NGL prices will remain at levels that will enable them to maintain their competitive position in major feedstock and fuel markets.

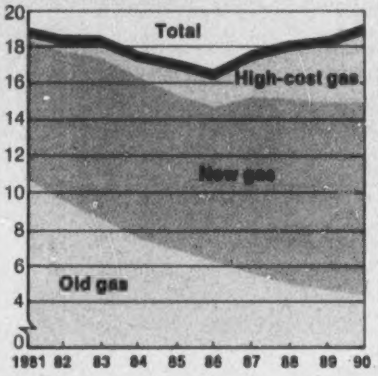
To get an idea how natural gas decontrol will affect NGLs, Resource Planning constructed three possible scenarios for decontrol:

- NGPA as is—the provisions of NGPA continue in effect.
- Full decontrol in 1985—all price controls are eliminated on Jan. 1, 1985.
- Phase-out of controls by 1988—phased deregulation of all gas supplies over a 36-month period.

Jones says that given Congress's propensity for delaying hard decisions, the 1988 phase-out is the most likely scenario.

Natural gas mix will change dramatically

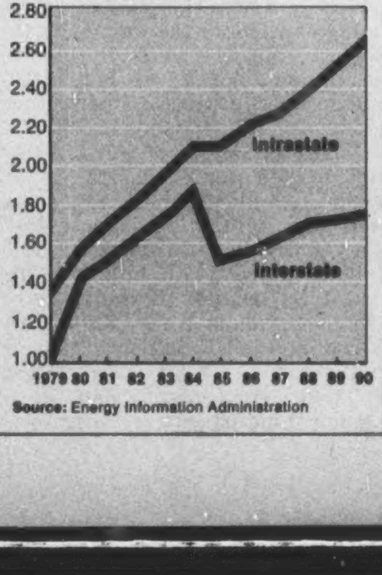
Production, trillions of cu ft



Note: Old gas, new gas, and high-cost gas as defined in Natural Gas Policy Act. **Source:** Energy Information Administration

Intrastate gas will be more expensive than interstate

Average wellhead prices, $ 1980 per million Btu



Source: Energy Information Administration

For the gas processor, the route to decontrol is important. The volumes of gas it has to work with and the pricing of recovered NGLs depend on how or if gas is decontrolled.

Extending controls to 1988, Jones says, means that the high prices for already-decontrolled gas (107) will continue. But the volumes are small enough that this extension would have little impact on a gas processor.

Under NGPA's partial decontrol scheme, large volumes of gas will be deregulated and gas prices will be relatively high. This would put the squeeze on processor profit margins, and processors will think about leaving the NGL in the gas stream.

However, according to Jones, complete decontrol by 1985 would lower the decontrolled price of gas to about the average gas cost. Under these conditions, NGL extraction would remain profitable.

Whatever happens, ethane will be the NGL that will be affected most by decontrol. For the petrochemical industry, that's significant, because more than 85% of all ethane goes into olefins plants as a feedstock. Use of ethane as an olefins feedstock has increased nearly 70,000 bbl per day over the past three years. Much of this growth has come from steam crackers designed for heavy liquids. Jones estimates that by 1985, these heavy liquids crackers will have the capacity to crack 158,000 bbl per day of ethane.

But, unlike light feedstock crackers that have limited flexibility, these converted plants will crack ethane only if it is more economical than naphtha or gas oil. Jones estimates that, in 1985, a gas oil cracker will value ethane at 35 cents per gal (in 1981 dollars).

If NGPA remains in force, shrinkage and the fuel cost of ethane from decontrolled interstate gas would amount to 42 cents per gal. Unable to tolerate such losses, processors would leave ethane in the gas. As a result, Jones estimates that 1985 ethane production would be about 176,000 bbl per day less than potential supply.

However, if gas were decontrolled fully by 1985 or even phased in gradually through 1988, almost all of the potential ethane could continue to be processed. And it could be priced attractively enough for a heavy liquids cracker.

Both phased or full gas decontrol probably would assure ethane's continued growth as an olefins feedstock.

U.S. will be squeezed out of basic petrochemical trade

Per cent share of world trade	Exporters 1979	1985	1990		Importers 1979	1985	1990
ETHYLENE DICHLORIDE							
U.S.	90%	29%	10%	Japan	73%	36%	58%
Western Europe	9	20	10	Asia-Pacific[a]	26	36	6
Canada	1	28	44	Communist countries	—	28	36
Middle East	—	23	28	Latin America	1	—	—
Latin America	—	—	8				
STYRENE							
U.S.	78	16	—	Western Europe	29	37	28
Canada	22	80	71	Latin America	25	12	10
Communist countries	—	4	2	Asia-Pacific[a]	20	26	22
Middle East	—	—	27	Communist countries	11	—	—
				Japan	9	20	19
				Middle East	6	5	7
				U.S.	—	—	14
LOW-DENSITY POLYETHYLENE							
Western Europe	45	38	13	Asia-Pacific[a]	42	55	48
U.S.	31	11	7	Latin America	24	17	17
Canada	5	28	37	Africa	23	26	24
Japan	19	9	—	Communist countries	7	2	14
Middle East	—	14	43	Middle East	4	—	—
HIGH-DENSITY POLYETHYLENE							
Western Europe	48	24	12	Asia-Pacific[a]	46	33	36
U.S.	36	34	11	Latin America	23	36	44
Japan	15	16	8	Africa	20	26	20
Canada	1	18	52	Communist countries	8	—	—
Communist countries	—	8	5	Middle East	3	5	—
Middle East	—	—	12				

a Excludes Japan. Source: Exxon Chemical

But if NGPA remains in force, look for a big shift back to heavy liquids.

Unlike ethane, most propane does not go into petrochemical feedstock. It goes into the fuels market where conservation and availability of alternate fuels will restrain demand regardless of the decontrol scenario.

But it probably would be the feedstock market that would feel the greatest impact from variations in decontrol scenarios. Jones expects 1985 propane prices to be about 9 cents per gal (1981 dollars) lower under full or phased decontrol than they would be if NGPA remains untouched. Like ethane, propane would lose its economic advantage under NGPA, and about 50,000 bbl-per-day less propane would flow into chemical plants.

Butane is a different story. How natural gas is decontrolled, or even whether it's controlled at all, will have little impact on butane market demand or pricing. It makes little difference to the gas processor. And, even in 1985, butane prices will continue to be dictated by refining values, even though its value as a petrochemical feedstock will play an increasingly important role.

Because natural gas and natural gas liquids are so vital to the chemical industry, it's easy to see why it is so concerned about what the Administration and Congress do about natural gas decontrol. A lot is at stake.

Not only will the outcome of decontrol influence the way the industry does business in its own domestic market, but it will help determine its performance in international trade, say industry spokesmen.

There's a degree of truth in that, but only a degree. Certainly the chemical industry has been a star performer on the U.S. export stage. Last year's chemical exports of $21.2 billion added $11.6 billion to the country's balance of trade. Petrochemicals alone contributed about $13 billion to $15 billion to that export total.

There's good reason, then, for the chemical industry to argue against a U.S. policy that encourages continued oil imports, natural gas imports from Canada and Mexico, and even expensive liquefied natural gas imports from Algeria while it maintains NGPA price controls that limit U.S. gas production.

But when push comes to shove, what happens to natural gas decontrol may have no bearing whatever on future prospects for U.S. petrochemical exports, especially the basic, commodity products such as high- and low-density polyethylene, ethylene dichloride, and styrene.

With or without decontrol, plenty of less expensive gas will be available somewhere else in the world to feed competing petrochemical industries. Saudi Arabia and other Middle East countries are a prime example. So, too, are Mexico and Canada. Additional low-priced competition will be emerging from communist countries in Europe, perhaps even from China.

How much basic petrochemicals these countries export will depend on how much they produce, domestic demand, when their plants come on stream, and how well these plants are operated. But in many countries, world-scale plants are going up that far exceed domestic requirements.

It's inevitable that these plants will aim for the export market. And they will do it with such force that the U.S. —and Europe and Japan— will not be able to hold them back.

A recent study by Exxon Chemical shows what might happen to U.S. commodity petrochemical exports. U.S. exports of ethylene dichloride (EDC), for instance, accounted for 90% of world EDC exports in 1979. By 1985, Exxon expects that share to drop to 29%, and by 1990 to only 10%.

Similar trends are apparent in low- and high-density polyethylene. Styrene is even worse. In 1990, the U.S. will be exporting no monomer at all, according to the Exxon study. In 1979, U.S. exports accounted for 78% of the world total. Last year, U.S. exports of ethylene derivatives were the equivalent of 8 to 10% of U.S. consumption. By 1990, that share will drop to 2%.

The year 1990 is still a long way off. Exxon's numbers may be off a bit. But the trend is inevitable and no possible scenario for natural gas decontrol will change it.

This in no way diminishes the importance of the gas decontrol issue for the chemical industry. It still sees NGPA as the villain as far as future gas supplies are concerned. □

Engineering plastics battle recession

Demand for these plastics was down overall in 1981 but is still growing for some products and likely will pick up in second-half 1982

Patricia L. Layman
C&EN, New York

Talk with any number of people in the engineering plastics business, and you can get about that many definitions of the term itself. But slowly, some key features start emerging, painting the polymers as high-performance materials able to withstand serious stress under hostile environments such as high temperatures for prolonged periods of time and allowing competition for markets with such materials as metals and glass. They are the most profitable and, historically, the fastest-growing segment of the plastics industry.

Even now, when the overall plastics industry is in dreary shape, engineering plastics are doing better. That's not to say they haven't been hurt by the economic downturn. Says one market researcher, "1981 was down—no question about it." But "down" for engineering plastics producers, in 1981 and probably through the first half of 1982, basically means demand and output that are level or only slightly down; some resins actually maintained a small—less than 4%—growth.

However, indications are that things will pick up in the second half of the year. And when that happens, marketers agree, engineering plastics will be well on their way back to the 12 to 15% annual growth rate they have been accustomed to, a growth rate expected to continue through the 1980s.

It's to capture some of that fast-growing business that the industry has been expanding and is continuing to put money into more expansions. In January, for example, General Electric announced a 10-year, $1.5 billion plan for expanding its engineering plastics program. And earlier this month it introduced what it calls a completely new family of polyme[illegible]lyetherimides, that will be m[illegible]eted under the tradename Ultem (C&EN, Feb. 15, page 6).

Phillips Petroleum completed a 3 million lb-per-year expansion of its polyphenylene sulfide plant at the end of last year, bringing total capacity to 9 million lb. It is adding another 500,000 lb of capacity this year, with yet another increase—to a total of 12 million lb per year—slated for 1983.

Mobay last year completed a new plant for making polycarbonates at Baytown, Tex., adding to its capacity. And Dow Chemical, which now has a pilot plant producing polycarbonate resins, plans to be in full-scale production by 1984.

Du Pont is constructing a new plant for its Zytel nylon in Japan, due for completion in 1983. Allied Corp. is expanding its capacity for fluoropolymers at Orange, Tex., with the expansion slated for completion this spring.

And at least two other producers of engineering plastics—GAF and Union Carbide—are contemplating new plants. Carbide is considering a plant for polyarylide resin, which it now imports from Japan, and GAF says that expansion of its polybutylene terephthalate polyesters "is in the cards."

All this effort is being aimed at a market that requires suppliers to have one important attribute: patience. Because marketers of engineering plastics are selling not so much product as performance, it takes time for customers to evaluate a product or work it into potential production and design schemes. Manufacturers are faced with the time required for testing to meet regulatory or insurance requirements—for meeting Underwriters' Laboratories requirements, for example, or Food & Drug Administration standards.

In fact, most marketers agree that it takes a minimum of two years to get from initial sampling of an engineering plastic to commercial sales. That kind of time and the often hefty amounts of up-front money frequently are difficult for hard-pressed managements to accept, marketers say. However, its acceptance is crucial to success in the business. As one marketer puts it, "It takes a lot of patience and a lot of staying power."

It takes a commitment, for example, to jump completely into the market and stay there as a serious

Nylon, polycarbonate lead engineering plastics

Millions of lb	1981 consumption
Nylon	275
Polycarbonate	250
Modified polyphenylene oxide	125
Acetal	95
Thermoplastic polyesters	55
Polysulfone	10
Polyphenylene sulfide	7
Others	1
TOTAL	818

Source: Celanese, industry estimates

1981 U.S. use of engineering plastics is still below 1978

Millions of lb	1981	1980	1979	1978	1977
Electrical/electronic	255	249	293	231	202
Transportation	155	159	197	187	173
Building and construction	75	75	106	81	72
Industrial/machinery	75	75	93	96	85
Consumer/institutional	50	49	53	54	51
Packaging	30	29	38	27	23
Other	90	91	71	71	64
TOTAL	730	727	852	747	670

Note: Excludes exports. Includes engineering plastics: nylon, acetal, polycarbonate, polyphenylene sulfide, thermoplastic polyester, polysulfone, and modified polyphenylene oxide. Includes specialty plastics: polyimides, polyamide-imides, and fluoropolymers. Source: Society of the Plastics Industry, industry and C&EN estimates

Eighteen firms have 1.5 billion lb of capacity for 11 plastics

	Plastic (capacity, millions of lb)
Adell Plastics	Nylon (20)
Allied Corp.	Thermoplastic polyester (5)
	Fluoropolymers (3)
American Hoechst	Nylon (20)
Amoco Chemical	Polyimide (3)
	Polyamide imide (3)
Badische Corp.	Nylon (11)
Bemis	Nylon (20)
Celanese	Acetal (125)
	Thermoplastic polyester (70)
	Nylon (40)
Du Pont	Acetal (80)
	Thermoplastic polyester (25)
	Nylon (160)
	Polyimide (3)
	Fluoropolymers (20)
Firestone Plastics	Nylon (12)
GAF	Thermoplastic polyester (12)
General Electric	Polycarbonate (265)
	Thermoplastic polyester (130)
	Polyphenylene oxide (200)
	Polyether imide (10)
Goodyear	Thermoplastic polyester (10)
ICI Americas	Fluoropolymers (5)
Mobay	Polycarbonate (90)
	Thermoplastic polyester (20)
Monsanto	Nylon (70)
Phillips Petroleum	Polyphenylene sulfide (9)
Rilsan Corp.	Nylon (18)
Union Carbide	Polysulfone (15)

Sources: Society of the Plastics Industry, Industry and C&EN estimates

competitor. GE, which claims a one-third share of the worldwide $2.9 billion-per-year market for engineering plastics, provides a case in point. As one of the first projects under its $1.5 billion spending plan for the next 10 years, it has begun a new engineering plastics center at Montgomery, Ala.

Construction is scheduled to begin in early 1983 for the first module, which will be for Lexan polycarbonate. It will include production facilities for raw materials bisphenol A, chlorine, and caustic soda, polymerization facilities for polycarbonate resin, and a finishing plant for blending and coloring. Initial output is scheduled for late 1984 or early 1985, with production topping 100 million lb per year of Lexan. According to the company, each of the individual plants will incorporate new technology that the firm has developed over the past few years. Other modules envisioned by GE for the Montgomery site will produce other, unspecified engineering resins, and, by the late 1980s, basic silicone manufacturing.

The engineering plastics business also takes a willingness to customize a product, tailoring a resin for a specific customer or application. Du Pont, for example, points out that it sells 250 different kinds of nylon. A market of 1 million lb per year would be considered "gigantic" for engineering plastics, says another market manager; 10,000 lb per year is considered quite respectable. "In this business, you have to be prepared to consider everything," he says, adding, "The key to success is deciding what to pursue, and how far."

One factor making low-volume markets bearable, of course, is the ability of producers to charge for their custom development work and technical service. Prices of basic engineering plastics—generally acetals, polycarbonates, modified polyphenylene oxide, nylon, thermoplastic polyesters, polysulfone, and polyphenylene sulfide—run from a little more than $1.00 per lb to about $4.00. GE's new polyetherimides will sell for $4.25 to $6.50 per lb for the base resin. And prices of the more exotic materials, including polyimides, polyamide- and polyesterimides, and fluoropolymers, can start at $10 per lb and head upwards.

But even prices this high can prove acceptable to customers seeking to cut the weight of their products—one reason, for example, that engineering plastics are finding applications in the auto industry—or to customers seeking to simplify a production process by molding in one part, with colored resin, what otherwise might have been six separate components bonded or otherwise joined together and then painted.

Engineering plastics suppliers can provide resins to meet a host of needs: by filling resins with glass fiber, for example, or other compounds; by developing copolymer systems; or, increasingly, by developing what are basically alloy systems. Alloys always have been important to engineering plastics. GE's Noryl, for example, is a polyphenylene oxide modified with styrene. And Uniroyal was able to enter the engineering plastics business with its Rovel alloy, a styrene-acrylonitrile matrix saturated with a proprietary olefinic elastomer, probably a copolymer of acrylonitrile, EPDM (ethylene-propylene-diene-monomer), and styrene, rather than acrylonitrile-butadiene-styrene (ABS), which can have ultraviolet stability problems.

However, alloys are becoming increasingly important to the industry as suppliers attempt to cut already steep development costs. Among the more promising developments are the so-called elastopolymers—blends of polybutylene terephthalate with elastomers, for example, to replace rubber parts that have to be vulcanized.

At a plastics conference last year, for example, Bennett Nathanson, manager of commercial research and new business development at Celanese Plastics & Specialties Co., targeted several such alloys as potential stars. Elastomers are being teamed up with a number of resins. Du Pont and Allied alloy them with nylon, for example, and GE alloys elastomers with polybutylene and polyphenylene oxide. Styrenics are the other major alloying materials—ABS with polysulfone, in one Union Carbide product, for example; ABS with polycarbonate from Mobay and Borg Warner; and acrylic styrene with polybutylene terephthalate from Toray.

Copolymers and alloys also are seen as a latchkey to the engineering plastics market for producers of such conventional resins as ABS and polystyrene, eager to gain a share of the more lucrative tailored-resins business. They are developing grades that can provide at least some of the properties stipulated for engineering plastics. And they are tailoring their efforts to win niches where classic engineering resins might be overengineered for a use.

Borg-Warner, for example, is developing modifications of ABS that can meet some engineering plastics demands. Its efforts are beginning to pay off, enough so that the company says that a significant share of the output from its new 150 million lb-per-year ABS plant nearing completion will go into the engineering resins market. Similarly, Dow, which already has decided to get into the business with its polycarbonates venture, is emphasizing performance plastics with polystyrene, and has some grades it is aiming at this market. As one marketer in commodity plastics puts it, "When plastics first came out, they got a bad name because they were underengineered. Then designers went wild and overengineered. Now, there is getting to be a healthier appreciation of the properties required for an application, and people can select the plastic that's appropriate." ◻

1981 sluggish for West German chemical firms

Although total sales were up almost 10% over 1980, prices barely kept up with inflation, production was up only slightly, and profitability was down

"It was not a glamorous year." That's how Herbert Grünewald summed up the position of the West German chemical industry in 1981 when he gave his first presidential address to the Verband der Chemischen Industrie (Chemical Industry Association) in Frankfurt recently. Grünewald, who is also chairman of the giant chemical firm Bayer, took over the association's presidency from Karl Wamsler, who completed his two-year term at the end of 1981.

In his state-of-the-industry message, Grünewald notes that chemical sales in West Germany last year approached $53 billion (based on a conversion rate of $1.00 = 2.24 Deutsche marks on Dec. 31, 1981), up 9.5% from 1980. On the other hand, sales of chemicals in West Germany produced by local companies rose only 5.1% to $31.2 billion. Moreover, profitability last year slipped to 1.5% of net returns from 1.8% in 1980 and from a relatively high 2.4% in 1979.

Grünewald: not a glamorous year

One reason for the worsening of profitability is the low level of the industry's plant utilization. For basic chemicals and petrochemicals generally, this now stands at 75% of capacity, a drop from 78% in 1980.

Another factor that influenced profitability adversely was the rise in feedstock and energy costs, which increased up to 50% last year for a large segment of the West German chemical industry. Despite the fairly stable 1981 price of oil and naphtha in U.S. dollar terms, the weakness of the Deutsche mark meant that West Germans had to pay considerably more for these items in their local currency much of the year.

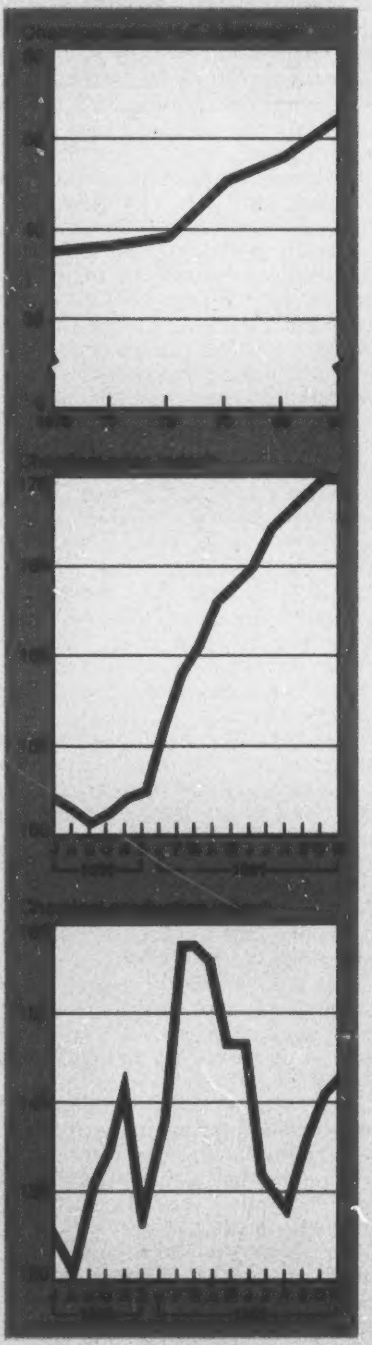
One advantage stemming from the weakness of the mark was that it served as a spur to chemical exports. These reached an all-time high of $24.2 billion, 14.3% greater than in 1980, and accounted for 45.8% of the chemical industry's total sales. Between 1976 and 1981, West Germany's chemical exports grew at an average annual rate of 9.4%, compared to a 6.8% average annual increase in total sales during the same period.

It was largely on the strength of exports that West Germany's chemical sales reached their 1981 level, Grünewald points out. Compared to 1980, exports to the U.K. were up 32%, to the U.S. 31%, to Japan 29%, and to France 10%.

Ironically, imports of chemicals into West Germany last year also increased to an all-time high. At $13.5 billion, imports last year exceeded those in 1980 by almost 14% and accounted for nearly 26% of total sales. Indeed, during the past five years, West German chemical imports have grown 11.6% annually, outpacing the growth rate of both exports and overall sales.

The two basic parameters of the industry—production index and price index—also point up the flat state of the West German chemical economy. Between January and November last year (December's figures haven't been reported yet), the production index averaged 144 (1970 = 100). That was a mere 1.6% improvement on 1980 during the like

West German sales, prices up; production is wavering



a $1.00 = 2.24 Deutsche marks as of Dec. 31, 1981.
b Base year for index is 1970 = 100.

period. The advance in the monthly price index was larger. But the 8.4% gain in 1981 barely kept ahead of inflation.

Not all segments of West Germany's chemical industry have their backs to the wall, however. Pharmaceuticals, pesticides, and other specialty products still demonstrate growth and profitability, Grünewald notes.

Those areas that have undergone the greatest decline for the most part are chemicals that are highly dependent on oil as feedstock. Commodity thermoplastics, for instance, have experienced sharp falls in selling price and output, largely because of intense competition in the marketplace, and are causing a severe financial drain on producers. Manmade fibers, too, still are experiencing trouble, despite the major production restructuring that companies have been working on for the past few years. Other classes of products that are going through a weak spell are fertilizers and photochemicals.

Despite all this, the chemical labor force has remained remarkably stable. Last year, the total declined a mere 0.5% to 548,000. "Our aim has been not to cut the number of workers," Grünewald says. "We stress short-time working instead."

Still, relatively few workers are on short time. In December they amounted to 5500, about 1% of the total. Nevertheless, that was some three times greater than the number last August.

For 1982, Grünewald believes that chemical industry capital spending will decline from last year's $3 billion or so, which equaled the amount spent in 1980. Asked about sales and earnings for this year, he responds that much will depend on how the economy develops, not only in West Germany, but in the other leading industrialized countries.

It's still too early to predict the outcome of next spring's wage and benefits negotiations with the unions. Last year's direct pay settlement was 5.5% ahead of 1980.

But of one thing Grünewald is certain. Because his industry is 80% dependent on oil, there will continue to be a gap between costs and profits. "We must seek product price increases in 1982," he says, "to cover our higher costs and to improve our profit structure." He acknowledges that this won't be easy because of competition and resistance by customers who find it difficult to pass on higher prices.

Dermot O'Sullivan, London

CHECKOFF

■**Brazil**—Ultramold Resinas Sinteticas will build plant for production of amino plastics in Camacari, near Salvador, Bahia; cost and capacity have not been disclosed. Ultramold Resinas Sinteticas, new joint venture of Perstorp of Sweden and Ultra Enpreendimentos e Participacoes, the Brazilian Petrochemical Group, was established for production and sales of amino plastics. New plant, using Perstorp technology, is scheduled to be completed in 1983.

■**Canada**—Federated Cooperative Ltd. and Saskatchewan government will build $7.1 million (Canadian) pilot fermentation ethanol research plant at Canora to have annual capacity of 2.5 million gal of ethanol made from barley.

Liquid Air Corp. has formed new industrial gas company called Liquid Air Energy Corp., which will operate through Liquid Air's Canadian subsidiary, Canadian Liquid Air Ltd. Headquartered in Calgary, new company will serve energy-related industries with construction and engineering of cryogenic plants, industrial gas application technology, and supply of industrial gases.

PPG Industries has completed $20 million plant expansion that more than doubles sodium chlorate capacity at company's Stanchem chemical complex in Beauharnois, Que. Expansion adds 38,000 tons of annual capacity, bringing total at site to 73,000 tons per year.

■**Chile**—Sociedad Chilena de Litio will invest $61 million in project in Salar de Atacana region to produce 14 million lb per year of lithium carbonate. Company is 55% owned by Foote Mineral and 45% owned by Corporacion de Femento de la Produccion of Chile. Fluor Mining & Metals, Redwood City, Calif., will perform engineering, procurement, and construction-management for project.

■**China**—Jacobs Engineering has been awarded contract for feasibility study for two facilities to recover total of 1.2 million tons per year of potash from brine of Chaerhan Lake, a dry lake 2500 miles west of Beijing, in Qinghai province.

■**West Germany**—Catalytic Inc. of Philadelphia has completed chlor-alkali plant at VEB Chemiekombinat in Bitterfield; new plant uses 104 electrolytic cells to provide capacity for 372 metric tons per day of chlorine and 419 metric tons per day of caustic soda. Technology licensed from Diamond Shamrock.

■**Japan**—Du Pont has signed letter of intent with Toray Industries to form venture to produce and market Hytrel polyester elastomer in Japan; marketing will begin early this year. Set up as new division of Toyo Products Co., a joint venture between Du Pont and Toray, new venture is planning plant to make Hytrel by mid-1983.

■**Mexico**—Jacobs Engineering will provide basic engineering, procurement, supervision of detailed engineering, personnel training, and startup assistance for estimated $25 million potassium chloride recovery facility to be built at Cerro Prieto in state of Baha California Norte. Plant, which will be built for Fertilizantes Mexicanos, will recover potassium chloride from residual brines discharged from geothermal electric generating station.

Polycyd has completed 150 million lb-per-year polyvinyl chloride plant near Tampico. This is Polycyd's second PVC operation, other being at La Presna, near Mexico City. Polycyd is joint venture of B. F. Goodrich and CIDSA group of Monterrey.

■**Portugal**—Quimigal has put on stream 10,000 ton-per-year polyether polyols plant at its industrial complex at Barreiro, near Lisbon; plant was designed and supervised by Petrocarbon Developments Ltd. based on Diamond Shamrock technology.

■**Venezuela**—Fluor will perform $2 million feasibility study for proposed petrochemical complex in Eastern Venezuela, close to Barcelona; if built by Petroleos de Venezuela, complex would use feedstocks from existing refineries and gas plants as well as from facilities yet to be built.

Chemical & Engineering NEWS

A1250-1 3/82

Ferrocenophane exhibits fascinating, at times peculiar, behavior Page 23

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Chlor-alkalies losing former market strength

A Key Chemicals Review Page 10

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Chemical & Engineering NEWS

Cover: FMC's soda ash mine at Green River, Wyo.

2 Letters

Concentrates

8 Business
15 Government
19 Science/Technology

The Departments

33 New Products
38 Meetings
39 People
52 Newscripts

News of the Week

- ***Existence of unusual new life form*** *100 to 1000 times smaller than smallest known virus is suggested by research at University of California, San Francisco.* ***Page 4***
- ***All further use of urea-formaldehyde foam*** *insulation has been banned by the Consumer Product Safety Commission.* ***Page 5***
- ***Procter & Gamble made a rare appearance*** *before security analysts, talked about plans to emphasize its international operations, continue heavy R&D funding.* ***Page 5***
- ***Funding for fusion research*** *at Lawrence Livermore National Laboratory is being provided by the Japanese.* ***Page 5***
- ***A 50% cut in sulfur dioxide emissions*** *in eastern Canada and the U.S. by 1990 has been proposed by the Canadian government in bilateral talks on acid rain.* ***Page 6***
- ***Reorganization at the National Academy of Sciences*** *is aimed at removing some of the competition for projects.* ***Page 6***

Business

- ***Chlor-alkalies look frayed*** *as demand softens for caustic soda, market strength diminishes for soda ash, and slowing plant expansions spell gloom for chlorine.* ***Page 10***

International

- ***Canada's leading chemical companies*** *caught in a cost-price squeeze as 1981 combined earnings plummet.* ***Page 14***

Government

- ***Amount of data required*** *in premanufacture notice for chemicals cut in Office of Toxic Substances proposal.* ***Page 16***

Science

- ***Peculiar behavior of ferrocene derivatives*** *interest IBM research chemists who have found a C-H-C hydrogen bond in ferrocenophane anion.* ***Page 23***
- ***Unstained, isolated organic molecules*** *on a metallic surface can be visualized with new type of microscope.* ***Page 27***

Technology

- ***Development of synthetic fuels industry*** *is essential despite current oil surplus, says IGT president.* ***Page 28***

Books

- ***"Are Pesticides Really Necessary?"*** *presents a balanced view of the hazards and benefits of chemical pest control.* ***Page 34***

ACS News

- ***ACS broadening on-line information services*** *to strengthen computer-related activities and improve information delivery.* ***Page 37***
- ***Committee formed to search for Mariella's successor;*** *ACS board lists duties of the executive director of ACS.* ***Page 37***

Luster dims for chlor-alkali producers

Demand for caustic soda, in short supply for some time, is now softening; soda ash market is losing strength; chlorine is worst of all

Bruce F. Greek, C&EN Houston, and William F. Fallwell, C&EN Washington

The rags and riches makeup a year ago in U.S. chlor-alkalies has changed decidedly. The rich products of 1981—caustic soda (sodium hydroxide) and soda ash (sodium carbonate)—now have become a bit frayed. And the poor end of the business in chlorine is an out-and-out welfare case.

Fundamental long-term questions already on the table about this $5.6 billion per-year business have become even more serious. Adjusting to the no-growth, recessionary world of the early 1980s guarantees a shakeout in chlorine and caustic soda. Plant shutdowns already have started. For soda ash, some letup seems in order for its vigorous investment pace of the past few years.

The only bright spot in the chlor-alkali picture at the moment is a strong drive on process technology to save costs. Some dramatic gains could materialize by the mid-1980s in all three products.

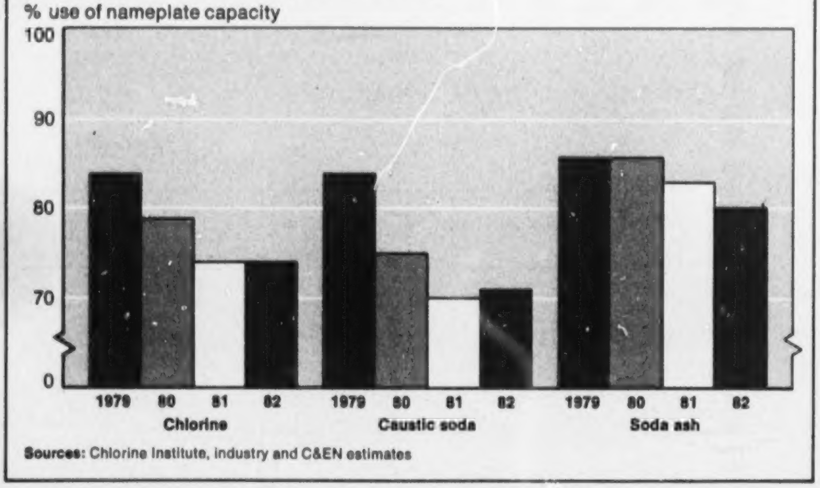
At the moment, optimism in chlor-alkalies has become quite relative. "Good performance" in 1982 and beyond will be much less than in the past. For 1982 to be a "good" year, production need only match 1981. For succeeding years production need go up only 2 to 3% annually. A jump of 5% might mean a banner year, although it was average in the past.

Producers hoped a year ago too that production would hold even. But 1981 production of chlorine and caustic soda was off 6%, and soda ash was flat. The same thing happened in 1980 compared to 1979.

Key Chemicals

Current production is well down from early 1981. It appears to be holding at about December 1981 levels, when chlorine plants ran at a lowly 65% of nameplate capacity. A substantial pickup is expected, however, and will be needed in the second half of 1982 to get production back up to 1981's. Still, some analysts say that signs of a pickup in consumer demand must appear this month and in April for a large chlor-alkali production gain in the second half.

Plant-use levels stay low in 1982



Sources: Chlorine Institute, industry and C&EN estimates

Any pickup will need to be sustained beyond the second half for the chlor-alkali industry to regain its former health. How long that will take depends on future growth rates. More and more, opinion points toward rates close to the low levels expected for constant-dollar gross national product. This means an average of 2% annually, well below the 1970's 5 to 7%. This will be especially so if exports of the two alkalies and of chlorine derivatives slump under pressure from foreign competition.

If such a slow pace develops, three big changes are in store. One will be an end to large plant expansions for several years. In 1981, the last of the large chlorine plant expansions of the past half-decade was completed. This year, the last of similarly large expansions in natural soda ash will be nearly completed.

The second major change will be numerous shutdowns of old chlorine-caustic plants. Pennwalt has one in store for mid-1982 at Calvert City, Ky., and more are expected. Chlorine is vulnerable in this regard, since 10% of total capacity is in small plants of less than 275 tons per day.

The third change will be heavy cost-cutting through new technology. For chlorine, new cell technology including the freshly introduced membranes might reduce electric power consumption a third, possibly reaching a long-sought goal of 2000 kWh per metric ton of caustic. Several relatively small plants using new membrane cells have gone into operation around the world, and more are due this year and next. But it will take most of this decade for this technology to have much effect on U.S. production.

For soda ash, new-process solution mining of the trona ore in place of mechanical methods also could reduce costs substantially. Much of the decade might be needed for this change to occur, but the payoff could be big. Solution mining could make U.S. soda ash so much cheaper than foreign synthetic product that no political efforts abroad could block large U.S. exports.

These changes, though important, unfortunately won't help chlor-alkalies very soon. For the sobering details on 1982, see the following pages.

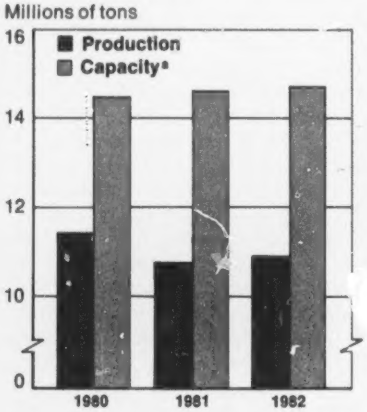
Key Chemicals

Cl_2

Chlorine

- ***Production depressed***
- ***Capacity rise over***
- ***Deep price discounts***

PRODUCTION/CAPACITY



a First quarter.

HOW MADE

Electrolysis of NaCl brine; recovery from hydrochloric acid; coproduction with sodium; electrolysis of KCl brine

MAJOR DERIVATIVES (U.S.)

Ethylene dichloride 20%, other chlorinated C_1, C_2 hydrocarbons 10%

MAJOR END USES (U.S.)

Organic chemicals and plastics 70%, pulp and paper 10%

FOREIGN TRADE

Negligible

PRICES

Posted prices $145 per ton Gulf Coast; discounting widespread

COMMERCIAL VALUE

$1.5 billion for production, 1982

Chlorine, the pungent green gas, has become more toxic to its producers than to anyone else. It isn't just the worst off of the U.S. chlor-alkalies; it could well be the financially sickest major product in the chemical industry.

That's a strong statement, but chlorine has qualifications. A combination of miserable markets, overinvestment in plants, and soaring energy costs has left chlorine thoroughly crippled. Rejuvenation could take until the mid-1980s.

Here's a startling statistic. Chlorine's real price hasn't changed a whit since 1977. That means its constant-dollar value for total production has dropped more than half. Formerly the dominant product financially from chlorine-caustic plants, chlorine is now worth only 45% as much as caustic soda.

Chlorine producers hope output from their plants in 1982 will match or slightly exceed 1981 production of about 10.8 million tons. 1981 chlorine production was off about 6% from 1980's 11.5 million tons. And 1980 was down 6% from the record 12.2 million tons in 1979.

After this cascade of production drops, return to the 1979 level could be some time off. Instead of the former 5 to 7% annual growth rates for chlorine production, current thinking calls for 2 to 3%, assuming the economy recovers substantially. Counting 1982 as a no-growth year, it could be 1986 or later before 1979 production again will be equaled—not a happy prospect for a product once known for continued growth.

To no one's surprise, little or no new chlorine plant capacity will be added over the next five years. The last large capacity addition, Convent Chemical's at Convent, La., with 800 tons a day of nameplate capacity, came on stream in 1981. The first-quarter 1982 capacity total is 14.7 million tons per year.

A few smaller additions are in the works, but for practical purposes expansion has stopped. Until existing capacity is again run at historically comfortable levels (above 90%), little incentive likely will exist to add more.

Indeed, there is compelling incentive to reduce capacity by closing plants. Pennwalt is leading the way this year with planned shutdown at Calvert City, Ky. Other closings are expected.

So 1982 and subsequent capacity seems set for a moderate decline. Old, small plants are likely to be shut down as producers with captive (in-house) markets in pulp and paper and other industries find it cheaper to purchase chlorine and caustic outside. Total shutdown capacity now is not expected to exceed 5% of current capacity, perhaps 500,000 tons per year.

Hence, a clutch of shutdowns won't do much for chlorine's operating rate anytime soon. For 1982, plant use might average 74% if demand picks up in the second half. This would be down from 75% in 1981.

Currently, plant operating levels are well below such rates. Plants are running only slightly above the 65% rate of late fourth-quarter 1981.

Chlorine producers are banking heavily on demand recovery in polyvinyl chloride, the largest of hundreds of identifiable chlorine uses. But PVC depends heavily, and unfortunately, on housing. In line with the housing industry, PVC currently is in dismal shape and is not expected to recover even slightly until late spring at the earliest. Because of the time needed to fill the production pipeline from chlorine to the finished plastic, a pickup in this chlorine market will wait at least until summer.

Other uses of chlorine are dominated by organic chemicals, notably industrial and commercial solvents and cleaners which are dependent on industrial production. Since production is off in metalworking and related industries, demand for chlorine for such application has sagged. To a lesser degree, the market for chlorine is down in pulp and paper.

This market rundown makes a dreary recitation, and 1982 for chlorine may be sheer survival time. Chlorine has been through this kind of market wilderness before, in the early 1970s. At that time, too, its price was heavily discounted, and plants were running fairly low. But the operating rate today is far lower, and there is no market boom in sight like the PVC construction pipe bonanza that did so much to pull up chlorine demand in 1973 and 1974. This time around, producers will have to help themselves first, by trimming back old plant capacity and streamlining use of their largest cost item, electricity.

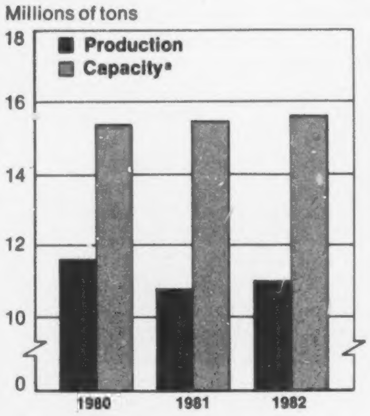
Key Chemicals

NaOH

Caustic soda

- ***Demand less robust***
- ***Capacity flat***
- ***Prices high, less firm***

PRODUCTION/CAPACITY



a First quarter.

HOW MADE

Electrolysis of NaCl brine

MAJOR END USES

Chemical manufacture 50%, pulp and paper 20%, soap and detergents 5%, petroleum refining 5%

FOREIGN TRADE

Exports—down to about 1.1 million tons in 1982; imports—small, probably under 100,000 tons in 1982

PRICES

Posted at Gulf Coast plants $275 to $285 per ton for 50% liquid grade; higher at other locations and for special grades; recent increase resisted

COMMERCIAL VALUE

$3.3 billion for production, 1982

Caustic soda appears finally to have found a ceiling in its spectacular rise in the past decade. From an unwanted coproduct all but given away, the extremely alkaline material has been transformed into possibly the chemical industry's most wanted major product. It is the only one consistently listed in short supply throughout U.S. manufacturing by the National Association of Purchasing Management.

But all such meteoric rises come to an end. In the past few months, some regional caustic customers have resisted price increases. This would have been unthinkable a year ago and hints a peaking for caustic. Caustic's real price probably had gone up tenfold in the past decade before the recent resistance.

Another hint of softness is that caustic has gone off allocation (new-order restrictions by producers). Although this move has allowed a short-term increase in sales, the general outlook for the year has clouded. Caustic's high price structure could hold down exports and curb further U.S. sales increases. In addition, several major industries that require large amounts of caustic—chemicals, pulp and paper, and oil refining—are suffering low operating rates from the recession.

Caustic soda's high price relates directly to its main long-term problem, sickly coproduct chlorine. The weak chlorine market puts caustic soda in a pinch, driving up the price not just to ration supply but to carry the cost of producing both electrolysis products.

Because almost all chlorine is coproduced with caustic soda, chlorine's market limitations will largely determine 1982 volume for caustic, too. The result is that output of caustic in 1982 will be about 11.0 million tons, up a bit from 10.8 million tons in 1981.

To a limited extent, consumers of caustic could shift to the other large-volume alkali, soda ash. New mine capacity coming on stream to produce natural soda ash this year could mean downward pressure on its price, making it more attractive than caustic to some users such as detergent phosphate and alumina producers.

The size of these potential shifts, fortunately for caustic producers, doesn't seem large. The total probably would be less than 5% of production, most likely closer to 2%, or between 200,000 and 300,000 tons. Most of this potential shift would be in detergent phosphates. Alumina producers are thought to have such high switching costs that their substitutions would be small, especially in light of the depressed state of the downstream aluminum business.

The dominant use of caustic, chemical manufacture, lays caustic open to cyclical ups and downs. Chemical uses are so diverse that their demand for caustic tends to follow the fluctuations of the chemical business cycle. The industry's slump in fourth-quarter 1981 affected caustic, too, although with a delay carrying into the current quarter.

Some growth continues for various caustic markets outside chemicals. For example, caustic used as an acid in petroleum production, especially in enhanced recovery of oil and natural gas, could add 1% a year to caustic's growth rate later on in the 1980s. Other uses, such as in pollution control of wastewater through neutralization, could grow relatively fast, though from a small base. These relatively new uses for caustic will not have much overall effect in 1982, however.

Inventory shifting may not help caustic this year either. Inventories of finished caustic in producers' plants were low during much of 1981 but rose in the fourth quarter. The end of allocation moved some inventory toward caustic-hungry customers, but the amount may be limited because of inventory-depressing high interest costs. For producers, these same high inventory costs plus weak demand for chlorine reduce incentive to run plants harder at a time when energy costs are still rising. In short, the inventory situation reinforces demand weakness in holding down caustic production.

Caustic demand has more influence on operating levels of chlorine-caustic plants than it used to, but chlorine demand is still critical. Getting rid of a chlorine surplus by dumping, as with surplus caustic years ago, isn't practical.

So caustic soda has a double challenge in 1982. Already saddled with chlorine's problems, caustic has a weakening market of its own. Its fast-rising days may be over for a while.

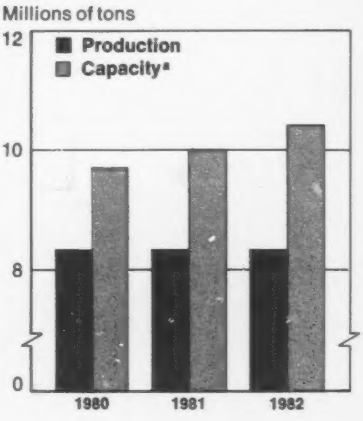
Key Chemicals

Na_2CO_3

Soda ash

- ***Demand flat***
- ***Capacity rising***
- ***Prices might weaken***

PRODUCTION/CAPACITY



[a] First quarter.

HOW MADE

Recovered from trona ore or brine; synthesized from salt and limestone using ammonia

MAJOR END USES (U.S.)

Glass 55%, chemical manufacture 25%, pulp and paper 5%, soap and detergents 5%

FOREIGN TRADE

Exports—declining in 1982 to under 1 million tons; imports—negligible

PRICES

$92 per ton at Wyoming plants; about $40 per ton higher in eastern U.S.

COMMERCIAL VALUE

$750 million for production, 1982

Soda ash has been a major success story in the past half-decade. An immense investment has paid off to change the industry's base from synthetic plants to trona ore mines in Wyoming.

Although even greater success may lie in store in Wyoming in the mid-1980s, soda ash has had to bow to the recession. It faces a decidedly weaker 1982.

Soda ash has joined the ranks of most other large-volume chemicals in the past year by going into clear oversupply. Its current situation contrasts sharply with its scarcity at the end of the 1970s.

The 1982 outlook for soda ash is an accentuation of trends from 1980 and 1981—a pause in demand while mine capacity rises. The resulting oversupply will be greater.

This year's markets will continue changing the same way they did in 1981. Slight declines in exports will combine with flat traditional markets and a slight gain in neutralizing uses, at the expense of caustic soda, to leave production at about 8.3 million tons.

Such forecasts assume a small improvement in the general U.S. economy in the second half of 1981. This improvement will be needed to offset what appears to be a significantly slower first quarter than in 1981.

The current slowing of production, due partly to severe winter weather, could last somewhat longer. Producers hope to reduce inventories built up in second-half 1981. For example, inventories apparently rose about 100,000 tons in November alone, based on preliminary data, before producers could come to grips with reduced orders.

Later in 1982, inventories are expected to rise again but for a largely technical reason. New capacity is due on stream about midyear at Tenneco's Wyoming plant. Some inventory increase naturally would occur from an expanded production base. Total capacity in the first quarter is 10.4 million tons per year.

The Tenneco plant eventually will have an annual capacity of 1 million tons. Its initial operating rate will be less, probably about half. For 1982 then, the real addition will be 200,000 to 400,000 tons of capacity.

Also reaching production this year will be a new-process solution mine of FMC in Wyoming. Involving a large capital investment, the project is still experimental. Actual output likely would be under the estimated nameplate capacity of 200,000 tons per year.

Success in FMC's solution-mining project could be crucial to the whole soda ash business. Both FMC and other companies looking at solution mining believe that the technique could mean significantly lower costs for soda ash than with conventional mechanical mining or from synthetic soda ash plants. If this potential works out, U.S. soda ash producers could gain in world markets. Most competing non-U.S. soda ash in the world is made synthetically and more expensively from limestone and salt.

However, the outlook for U.S. producers in world markets this year is flat at best. Exports might be down as much as 10% from 1981, when they totaled nearly 1.1 million tons or 13% of U.S. production. At work is a squeeze from slowing world economies, anti-import efforts of European producers, and competition from other nations.

In the U.S., the bright market spot for soda ash continues to be commercial construction. This area includes new glass-walled office buildings. Often big windows in these buildings are double glazed, adding to demand for flat glass, which is second among glass uses of soda ash. Such flat glass use could offset declines in automobile applications and be the best U.S. market for soda ash.

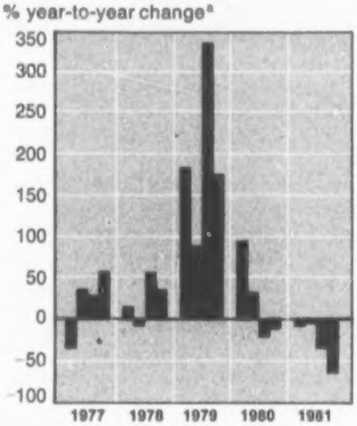
Containers, the largest use of glass and in turn soda ash, got through 1981 with no more than a 1% decline. The outlook for 1982 in this vital area depends on success of competing new plastic bottle machines. Assuming the machines make it, this use might be off 1 to 2% in 1982.

No other among soda ash's many uses will change enough to affect total demand significantly. The result is that producers will have to get through another year of no growth while mine capacity continues upward and prices probably weaken. The main frustration for producers may be the vital export market, which companies have been counting on for sustained growth but which has nothing to offer in 1982.

Canadian chemical earnings plummet in 1981

Although sales increased, Canada's leading chemical companies, caught in a cost-price squeeze, suffered drop in net income of 26%

Combined earnings: bad end to a bad year



a After-tax earnings of four largest publicly reporting Canadian chemical companies—Celanese Canada, C-I-L, Du Pont Canada, and Union Carbide of Canada.

The only thing good about 1981 as far as the Canadian chemical industry is concerned is that it's over. It was a year that the industry would rather not remember. But it is one that it will have a hard time forgetting.

With raw material costs rising rapidly under the country's controversial national energy program, and with selling prices stymied by a recession, both at home and in those all-important international markets, Canadian chemical companies found themselves caught in a classic cost-price squeeze.

Sales increased last year, but profits took a nosedive. Saving the worst for last, the pinch was particularly severe in the fourth quarter.

The combined results of four of Canada's leading chemical companies (C-I-L Inc., Celanese Canada, Du Pont Canada, and Union Carbide of Canada) tell the story vividly. Combined sales of these four companies increased 11.5% last year over 1980 to $3.5 billion (Canadian). But after-tax net income fell 26% to $144 million.

For these companies, the profit picture became worse as the year droned on. Net income was down only about 7% in the first and second quarters, compared to the comparable periods in 1980. But in the third quarter, the cost-price squeeze started taking its toll when profits dropped a sharp 35%. And in the murderous fourth quarter, they plummeted a disturbing 64%.

One company to escape with an increase in profits last year was C-I-L Inc. Company sales increased 14.5% and net income managed to advance 5.4%. However, even this gain has to be shaved because of the $5.2 million, after-tax, extraordinary expense associated with the company's move into new headquarters in Toronto.

C-I-L chairman and chief executive officer W. J. Mandry could have been speaking for the entire chemical industry when he said that company margins were hurt by rising raw material costs that couldn't be recovered in selling prices. In particular, he cites more expensive natural gas and phosphate rock for fertilizer and ethylene for C-I-L's plastics business.

Despite a 14.5% increase in sales, Du Pont Canada watched its profits slip 21.4% last year. But the company at least had the satisfaction of knowing that sales, which hit $1.1 billion last year, topped the billion-dollar mark for the first time. The company's 1981 earnings look even worse when the company's extraordinary charges are considered. The company took a $70 million extraordinary jolt as a result of withdrawing from the polyester textile filament business.

Of the four large Canadian chemical companies, Union Carbide of Canada was hardest hit on the bottom line. Despite a 4% sales increase, net income dropped a resounding 55% last year. The company's polyethylene operations were particularly hard hit. Prices of the polymer remained depressed throughout the year and company chairman John S. Dewar blames it all on an unwelcome combination of a worldwide polyethylene surplus and an abundance of low-priced raw material, particularly on the U.S. Gulf Coast.

If Canadian economic forecasters are right, the chemical industry probably has seen the last of the huge profit squeezes in this recession. Nobody is predicting a significant recovery, at least not until very late in 1982. But the outlook is for some improvement, if for no other reason than it's hard to contemplate things getting worse than they were last year.

Richard M. Clarke, president of Celanese Canada, is one who believes that 1982 will be better than 1981. However, he can look forward to the startup of his company's world-scale methanol plant in Edmonton, Alta., for some help. Most other Canadian chemical majors are reviewing their investment plans and may delay or cut back on some projects that have made Alberta a petrochemical boom area.

Earl Anderson, New York

Canadian chemical sales up, but net income drops

	FULL-YEAR 1981					
$ Millions (Canadian)	Net sales	Change from 1980	Net income	Change from 1980	Profit margin[a] 1981	Profit margin[a] 1980
C-I-L Inc.	$1149.9	14.5%	$ 54.3[b]	5.4%	4.7%	5.1%
Celanese Canada	373.0	11.0	20.3	−7.7	5.4	5.6
Du Pont Canada	1139.1	14.5	33.5[c]	−21.4	2.9	4.3
Union Carbide of Canada	827.3	4.1	36.1	−54.7	4.4	10.0
TOTAL	**$3489.3**	**11.5%**	**$144.2**	**−26.3%**	**4.1%**	**6.1%**

a Net income as percentage of sales. b Before extraordinary expense of moving offices to Toronto. c Does not include extraordinary charge of $70 million reflecting withdrawal from polyester textile filament business.

NOTE

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Cover 1, p. 3, 18-20, 22, 24-

25.

Chemical &
Engineering
NEWS

SBR leads slump in elastomers
A Key Polymers Review Page 18

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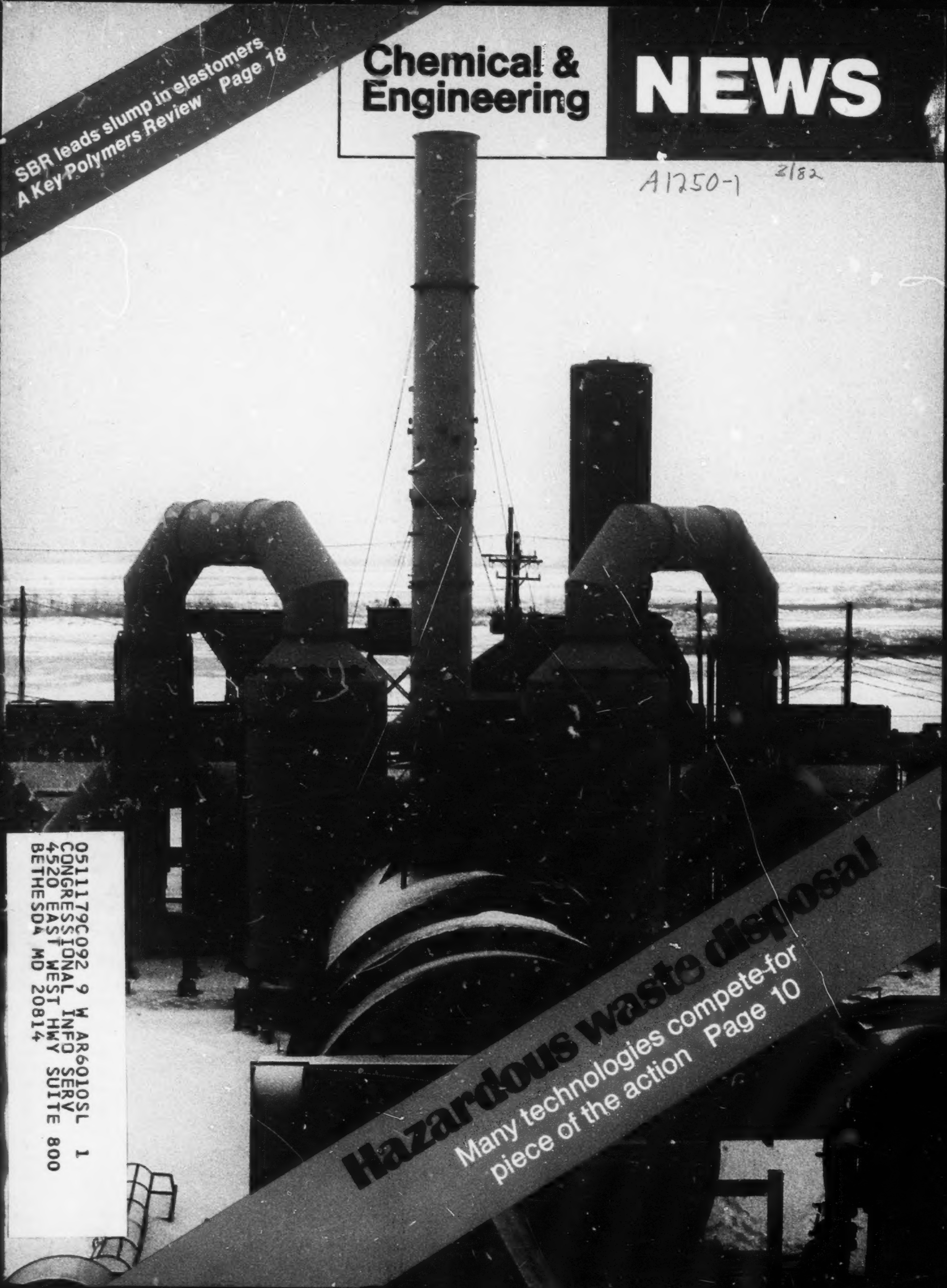

Hazardous waste disposal

Many technologies compete for
piece of the action Page 10

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Chemical & Engineering NEWS

Cover: SCA Chemical Services' 50,000 gal-per-day hazardous waste incineration facility nears completion on Chicago's South Side. Photo by C&EN's Ward Worthy

4 Letters

Concentrates
17 Business
23 Government
26 Science/Technology

The Departments
36 ACS Comment
44 Meetings
60 Newscripts

News of the Week

- ***EPA's relaxation of landfill regulations*** *to allow disposal of some liquid wastes meets with opposition.* ***Page 6***
- ***White-collar workers*** *at chemical, oil, and drug firms are target of union worldwide organizing campaign.* ***Page 6***
- ***NAS panel*** *to study government security controls on technology transfer and their effect on academic research.* ***Page 7***
- ***Technique to measure the sensitivity of an explosive*** *developed by researchers at Los Alamos National Laboratory.* ***Page 7***
- ***Project to assess feasibility*** *of converting high-level radioactive wastes into solids under way at New York site.* ***Page 8***
- ***Food Safety Council,*** *industry/consumer group, sets up system for regulatory agencies to determine food safety.* ***Page 8***

News Focus

- ***Methods for treating hazardous wastes*** *grow under spur of laws requiring environmentally acceptable disposal.* ***Page 10***

Business

- ***Elastomers are beginning to recover*** *from the demand drop of 1980 even though major synthetic SBR is sluggish.* ***Page 18***
- ***Wastewater treatment contract firms*** *are servicing many municipalities, anticipate $500 million business by 1990.* ***Page 21***

International

- ***Pequiven sets Venezuela's petrochemical industry*** *back on the road to recovery, faces challenge of boosting fertilizer.* ***Page 22***

Government

- ***Chemical firms' political action committees*** *growing in influence as contributions to political activities increase.* ***Page 24***
- ***OSHA's rethinking of cancer policy*** *welcomed by industry group.* ***Page 25***

Science

- ***Marijuana's long-term health effects*** *still not clear following study by a committee of the National Academy of Sciences.* ***Page 27***
- ***Chemical toxicity to be predicted*** *by new computer-based system.* ***Page 28***

Special Report

Of prestige and practicality: *James Bohning examines the first presidential selection process of a fledgling ACS.* ***Page 31***

ACS News

- ***C&EN draws up slate of proposed nominees*** *for 1983 ACS elections.* ***Page 37***
- ***ACS Council to act at Las Vegas meeting*** *on four petitions, dues increase.* ***Page 38***

Elastomers' recovery finally under way

Demand for SBR was down, but rebound in EPDM, nitrile rubber, and polybutadiene helped pull industry growth rate up to 2.2% last year

Patricia L. Layman
C&EN, New York

For producers of synthetic elastomers, last year was a painful one, but it was the pain of wounds starting to heal. After severe drops in demand in 1980, producers started seeing improvement in consumption for at least some elastomers, and the outlook for 1982 is that things finally will be getting better all around.

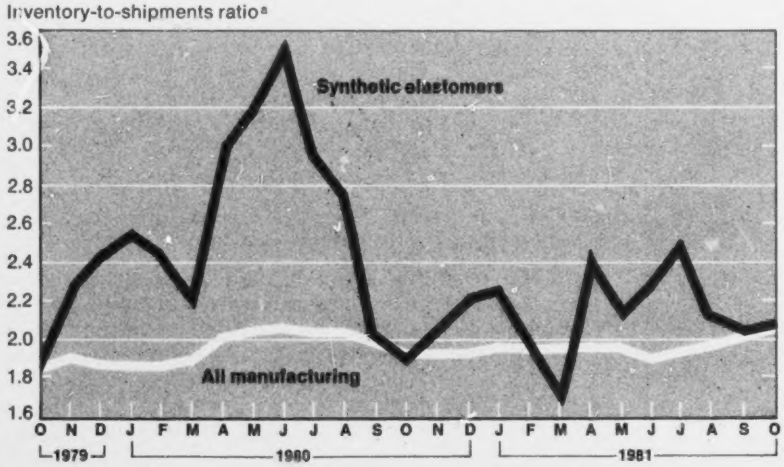
There were still a lot of negatives to cope with last year, of course. The major synthetic elastomer, styrene-butadiene rubber (SBR), which accounts for 53% of the industry's consumption, was off 1% in 1981, and that basically held down overall growth to 2.2% for the year. Neoprene demand also was down 1%, and polyisoprene down probably almost 20%. And exports, which had been up 10% in 1980, helping keep the total drop in 1980 consumption to 20%, were off: Preliminary figures indicate a decline from 449,145 metric tons to 367,000.

But beyond that, there were several bright spots last year. High on the list was ethylene-propylene-diene monomer (EPDM), demand for which was up 14%. Nitrile rubber use was up 8%, and polybutadiene posted a 7% gain. Butyl rubber was pretty much flat for the year—no gain, but no loss, either. Sales into traditionally heavy markets, housing and automotive, still were down, but sales of elastomers for the tire business were up, as replacement-tire sales spurted up. And, perhaps most important, what one producer calls "some hotsy-totsy markets" were becoming increasingly important.

Key Polymers

That can only be good news for synthetic elastomers producers, who have been faced with relatively high inventories over the past few years—even while operating, in the case of at least one elastomer, at less than 50% of industry capacity. And inventories are providing at least one worrying point for producers who watched some recovery in 1981 and who are hopeful about this year: a rise in inventories at the end of last year above the normal pattern.

High inventories hurt elastomers over past two years



a Seasonally adjusted. **Sources:** Rubber Manufacturers Association, Department of Commerce

However, there is no reason to write off 1982 yet. There are too many positive signs pointing to a recovery for that.

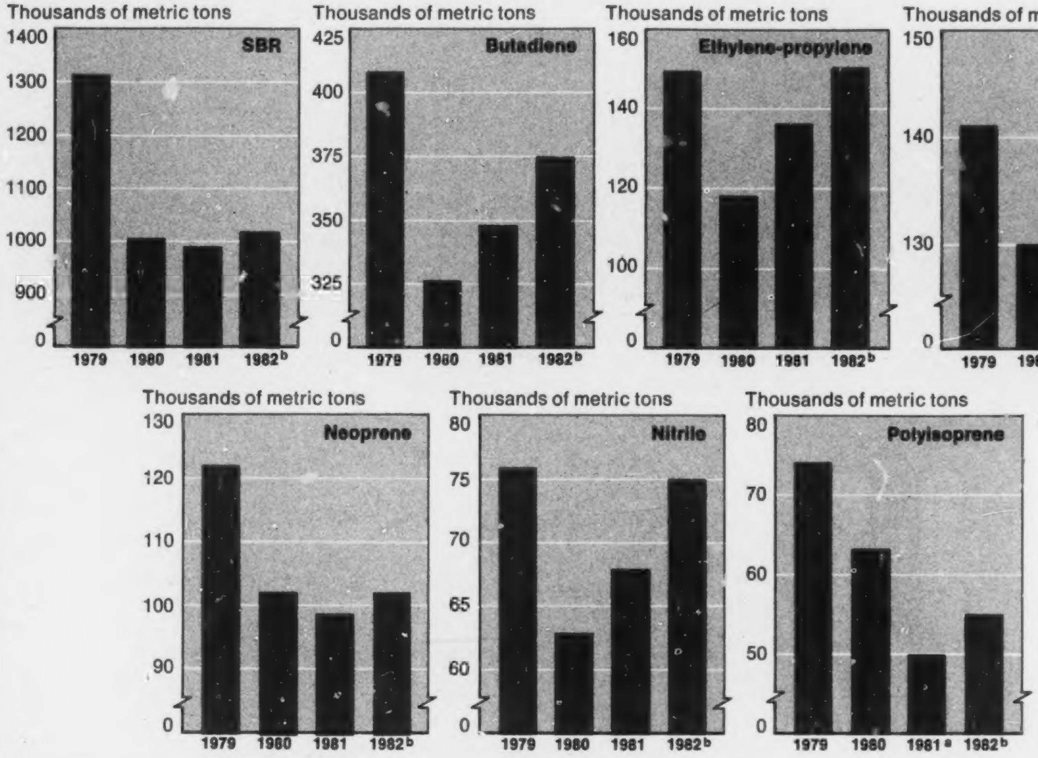
Leading the recovery was EPDM, which last year charted a 14% jump in consumption. That helped make up some of the ground lost when the material took a 23% decline in 1980. And producers of the elastomer are figuring optimistically that by the end of this year, it will have overcome all of that drop, to top 1979 consumption—the only elastomer to have recovered so quickly and completely.

In fact, the product has an appealing enough future to have enticed Polysar, the Sarnia, Ont.-based producer of synthetic elastomers, into the business, with the purchase in December of B. F. Goodrich's EPDM-polybutadiene plant in Orange, Tex. The plant gives Polysar a substantial presence in the polybutadiene market with the 72 million lb-per-year capacity in Orange complementing the production capacity it already has in Canada. But basically the company bought the plant to get into the EPDM business. The 22 million lb-per-year capacity may not be very large, but it gives the company an entrée into the markets.

Rather than being linked as heavily to tires as, say, SBR and polybutadiene, that end use accounts for only about 9% of EPDM consumption. Another 30 to 40% goes into the automotive business, in a variety of applications. These include radiator hoses, gaskets, and seals, for example—and the market is growing slightly because of substitution for other elastomers, such as SBR and neoprene, even though the automotive market itself is depressed.

But even more than that, EPDM producers are finding the target by raising their sights—to the roof, in fact. EPDM producers become ecstatic about the potential for the elastomer in sheet-rubber roofing, as a replacement for traditional builtup roofing materials. In fact, one producer attributes that application with pulling up the entire EPDM business, as the 30 million lb-per-year roofing segment chalked up a more than 50% growth last year.

Synthetic elastomer consumption: a slow recovery from drop in 1980



a C&EN estimates based on 10-month data. b C&EN estimates. **Source:** Rubber Manufacturers Association

As newer materials such as EPDM make inroads into traditional markets, however, the older elastomers are being given a correspondingly rough time. SBR production, for example, was down 1% last year, and neoprene (polychloroprene) was down a similar amount.

With only 99,000 metric tons of neoprene consumed last year, producers were operating at roughly 47% capacity, and those utilization and consumption rates aren't expected to change much this year. Neoprene continues to suffer because of the depressed condition of its two largest markets—automotive and housing. Even a significant smaller end use, neoprene latexes for shoe production, was down because the domestic shoe industry has been depressed lately.

But neoprene also is suffering as it comes under attack in some of the specialty markets, such as adhesives: Block copolymer thermoplastic elastomers, for example, are winning larger shares of the adhesives industry, besides replacing neoprene for such applications as cable and hosing and coatings for wire. And that is expected to continue. Growth prospects for neoprene between now and 1985 are 2 to 2.5% per year, whereas for the thermoplastics, it will be nearly three times that.

What some tire manufacturers say was a decided pickup in the sales of replacement tires helped boost consumption of polybutadiene to 349,000 metric tons last year, and the outlook for this year is 375,000 metric tons.

An improvement in the tire business, however, didn't do much good for butyl rubber, demand for which is expected to grow only slightly this year, from an estimated 130,000 metric tons in 1981 to about 132,000 this year. And producers see future demand growth coming along the same slow but steady lines: to 145,000 metric tons by 1985, and 158,000 metric tons by 1990. Most of that growth is, of course, dependent on the tire—and therefore auto—industries; if those businesses make an about-face and start a smart growth period, they will take butyl along with it.

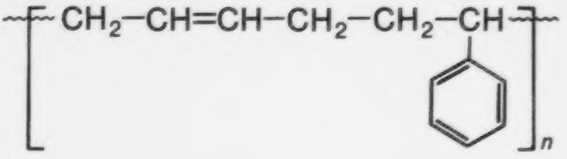
Polyisoprene, whose sole producer is Goodyear with a 60,000 metric-ton-per-year plant at Beaumont, Tex., continues to have consumption troubles, and also supply problems. The problem continues to be feedstock availability, limited by low operating rates of ethylene crackers. Demand had slipped 12% from 1979 to 1980, and it is estimated that consumption was down another 21% in 1981, from 62,615 metric tons to less than 50,000. Imports stood at 11,084 metric tons in 1980, and were running at 11,900 as 1981 ended, to help meet demand.

Petrochemical availability is hampering the polyisoprene business, but petroleum is helping the nitrile business, which chalked up the second-highest growth last year for elastomers, at 8%. As oil-drilling activity increased, so did the market for nitrile, particularly as blowout preventers for oil rigs. And other markets, in seals and gaskets, for example, continued strong.

The first two months of this year still haven't completed a turnaround, producers say—they are not completely out of the slump yet. And this year sees at least one major question mark, as tire workers' contracts expire with the major tire producers in April. But if there is no work disruption, and if the economy picks up any steam at all, 1982 will be better than 1981—it's just been a long, slow climb getting there. □

Key Polymers

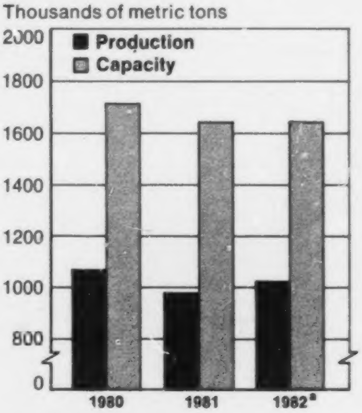
SBR



$$-\left[CH_2-CH=CH-CH_2-CH_2-CH(C_6H_5)\right]_n-$$

- ***Demand terrible***
- ***Operating rates down***
- ***Profits poor***

PRODUCTION/CAPACITY



a C&EN estimates.

HOW MADE

Free radical polymerization (mostly emulsion) of butadiene and styrene

MAJOR END USES

Tire and tread rubber 73%, mechanical goods 15%, latex 9%

FOREIGN TRADE

Exports—11% of production in 1981, down from 14.5% the year before; imports—more than 50,000 metric tons or 5% of production, a 23% increase over 1980 imports

PRICES

List prices run from 57.5 cents per lb for oil-extended tire grade to 70 cents per lb for nonoil-extended to 81 cents per lb for specialty grades; heavily discounted

COMMERCIAL VALUE

$1.32 billion for production, 1981

Last year, there was still enough optimism in the elastomers industry that producers of styrene-butadiene rubber (SBR) were predicting that consumption would be up nearly 10% for the year, from 1.006 million metric tons in 1980, to almost 1.1 million metric tons. But that didn't happen. Preliminary figures of the Rubber Manufacturers Association indicate that there was, instead, a 1% decrease, resulting in consumption of 996,000 metric tons of the elastomer in 1981. This year the industry is being more cautious, predicting an increase of less than 3%.

That's a dreary picture for SBR, which makes up some 53% of the total elastomers industry. And the long-term outlook for the material isn't much more encouraging. SBR producers are running their plants at only about 60% of capacity; the material is seeing traditional markets in a slump or being threatened by newer, more sophisticated elastomers; and a traditional strong point—exports—is off, with imports on the rise.

In 1980, exports of SBR totaled 145,463 metric tons, up 18% over 1979. But in 1981, the U.S. dollar began strengthening, and the export business plummeted. Full-year results aren't in yet, but indications are that exports dropped 20% in 1981, to about 115,000 metric tons. And imports, which historically have been relatively insignificant, rose nearly 25%, and are expected to have topped 52,000 metric tons.

Imports can't help but hurt an industry already operating at only about 60% of official capacity. That even takes into account the closing, at least temporarily, last year, of American Synthetic Rubber Co.'s SBR plant in Louisville. But at 70,000 metric tons per year, that was the smallest SBR plant in the U.S. to begin with. So its mothballing—ASRC may reopen the plant if economic conditions improve—had little impact on the business. One marketer suggests there has been some price stabilization, but others say that is sheer fantasy.

The major market for SBR is in tires and tread rubber, and the slump in that business helped keep consumption down in 1980. That market continued to be hurt, especially in original-equipment tires. The fourth quarter of 1981 was running at a 20-year low, although that was up from the first quarter of 1981, which was at a 35-year low—in other words, the same volume as right after World War II. On the other hand, demand for replacement tires, which make up about 80% of the tire market, was up 5 to 6% in 1981. That helped steady the SBR market, as well as the market for polybutadiene. Polybutadiene depends even more on the tire industry, and, in fact, saw an increase in consumption in 1981.

But for SBR, the year saw an intensifying effort on the part of producers of other elastomers to eat into markets that SBR had held securely. Several years ago, tires and tread rubber accounted for only about 63% of total SBR consumption, with the rest of the business spread among various mechanical rubber goods for both automotive and nonautomotive applications (25%), latexes (10%), and other miscellaneous items (2%). Last year, however, tires and tread rubber accounted for 73%. Demand for mechanical rubber goods had declined to about 15%, latexes to 9%, and miscellaneous about 3%. The elastomer is fighting to retain markets for such applications as hoses and tubing, molded parts, gaskets, and seals, as newer polymers such as EPDM offer performance improved enough to justify higher prices.

Even the tire industry doesn't offer SBR producers comfort. Short-term, 1982 sales of original-equipment tires are not expected to be any better than 1981 sales. Replacement tire sales are expected to show a growth of only about 2% with a similar long-range growth. Slowly but surely, as the auto makers downsize, tires are being downsized from a standard 15 inches to 14 inches, on down to 13 inches, and that means less SBR required. And more radial tires are being sold—66% of all passenger car tires sold in 1981, in fact—and they tend to last longer than bias-belted tires.

If any more production capacity is shut down—and producers agree that it will take a major closing to make any difference—the SBR business may well return to a profitable commodity status. But until then, or until any major new markets are developed, the business will be an increasingly depressed one.

Venezuela's petrochemicals back on track

Since taking over in 1977, Pequiven has returned many of its petrochemical units to sound operation, is now working to boost fertilizer

Pequiven (Petroquimica de Venezuela), the petrochemical arm of the state-owned oil company Petroleos de Venezuela, has come a long way since it took over from its debt-ridden predecessor IVP (Venezuelan Petrochemical Institute) in late 1977.

It has closed down some unprofitable operations. It has spun others off to other state agencies. With outside technical help, it has put many of its petrochemical units back on a sound operating basis, particularly its showcase olefins complex at El Tablazo.

Even Pequiven's detractors concede that the company's hard-core team of managers has put the Venezuelan petrochemical industry back on the road to recovery.

Now, Pequiven's big challenge, at least for 1982, will be to shape up the nitrogen fertilizer end of the industry. Among other things, Pequiven hopes to improve operations and increase production in its ammonia and urea plants located at El Tablazo in the Maracaibo region and at Moron in the central region.

More important, the company wants to increase the volume of fertilizer earmarked for the domestic agricultural market.

These goals became apparent in remarks made recently by Humberto Calderon Berti, Venezuela's Minister of Energy & Mines.

One big step in that direction is a change in fertilizer marketing responsibilities. After IVP was dissolved, Pequiven took over some of the fertilizer production responsibilities, while marketing was reconstituted in Venezolana de Fertilizantes (Venferca) under the Ministry of Agriculture.

This year, all of Venferca's functions will be centralized under Pequiven. As a result, Pequiven will handle fertilizer production, sales, distribution, and even imports of fertilizer materials.

Calderon Berti says that, rather than disrupt fertilizer distribution, the changeover likely will improve it. Meanwhile, Pequiven, along with the petrochemical coordinator of Petroleos de Venezuela, is making a major study of fertilizer pricing in the domestic Venezuelan market. They hope to come up with a pricing policy that guarantees a profit for Pequiven's fertilizer plants while, at the same time, protecting the country's agricultural sector from fluctuations in international markets.

Pequiven expects to receive about $121 million from Petroleos de Venezuela this year to use for petrochemical investment. About $41 million of this will be slated for the Moron complex, mostly to recondition and increase capacity of the fertilizer plants there.

At Moron, Pequiven operates a 198,000 metric-ton-per-year ammonia plant and a 248,000-metric-ton urea plant. Also at Moron are units to make the necessary heavy acids and finished fertilizers.

Most of the remaining $80 million will be spent at El Tablazo. A small portion of this, however, will go to Pequiven's headquarters operations in Caracas.

At El Tablazo, there are two 297,000-metric-ton ammonia plants and two 396,000-metric-ton urea plants. These units are owned and operated by Venezolana de Nitrogeno (Nitroven), but Pequiven owns 90% of Nitroven. The remainder is held by Instituto de Fomento Industrial (IFI) of Colombia.

Calderon Berti estimates that Venezuelan gross fertilizer production this year will reach 771,000 metric tons. If it does, it will be 236,000 metric tons, or 44%, more than was produced last year.

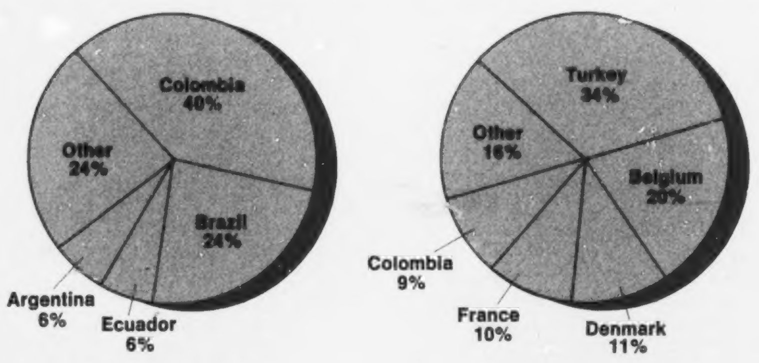
Meanwhile, Pequiven is shooting for an 88% increase in fertilizer shipments to the domestic market. Its goal: 398,300 metric tons this year.

But Pequiven isn't overlooking the export market, either. This year's target is 613,300 metric tons of all petrochemical products, an 18% improvement over last year.

Fertilizer exports will play a big role in determining whether Pequiven meets that target. Last year, ammonia and urea exports accounted for almost 85% of Pequiven's export total. Most of those shipments originated from El Tablazo, whose fertilizer plants are dedicated to the export market. Moron is designed primarily to satisfy the domestic market.

Earl Anderson, New York

Venezuela's fertilizer exports: Most urea goes to Latin America, most ammonia to Europe



Total urea exports, 1981 = 240,000 metric tons

Total ammonia exports, 1981 = 214,900 metric tons

Source: Pequiven

Political action committees' influence grows

PACs of chemical firms and unions were among the more than 2000 that spent millions on political activities during the 1980 elections

The influence, as well as the number, of political action committees (PACs) continues to grow as the Federal Election Commission reports that these groups spent $131 million on the 1980 election. And, although they are not among the heavy spenders, chemical company PACs did make some significant contributions.

The number of these political funding and campaign groups has skyrocketed in recent years as more and more organizations have become willing to throw their support behind political issues. Although not even possible until passage of the Federal Election Campaign Act of 1971, PACs really started blossoming after 1974 amendments to that act clearly defined just how a PAC could operate. At the end of 1974 there were just 608 PACs registered, but by 1980 FEC was dealing with 2785 active committees.

Final figures for the 1980 election from FEC show that 2155 PACs contributed directly to candidates running for federal office. PACs raised more than $138 million for that election, contributing $55.2 million to Congressional races, $1.8 million to the Presidential election, and spending millions more for their own political activities. PACs spent just $35.2 million for the 1978 elections.

As indicated in the preliminary totals published right after the election (C&EN, Nov. 10, 1980, page 22), corporate PACs raised more money for their candidates than did PACs sponsored by labor organizations. But both of these lost out to the efforts by PACs that are not associated with any organization and those PACs representing trade associations.

These latter groups raised $75 million for 1980 elections. And most of the funds were not given to individual candidates, but spent independently—that is, without any coordination or consultation with a candidate's campaign. The largest of these independent PACs is the National Congressional Club, which raised nearly $8 million. Compare this to the largest corporate PAC, the Chicago & Northwestern Transportation Co. at $668,000 and the largest union PAC, the United Auto Workers, at $1.8 million. The dominance of these independent PACs, which tend to support ideological goals or single issues, is expected to increase.

FEC's list of the largest corporate PACs did not include any companies that are primarily chemical producers, although some oil companies that do produce a considerable quantity of chemicals are on that list. These include Standard Oil (Ind.)'s Amoco PAC, which raised more than $385,000 as the third largest, and Tenneco PAC, which at $272,000 is in seventh place.

Although not listed as a major fund raiser, Dow Chemical should be. Dow PACs raised almost $338,000 for 1980, but because it was done through eight regional PACs, FEC cannot lump the total Dow effort together.

On the worker side of the chemical industry, the chemical unions have their own PACs. The Oil, Chemical & Atomic Workers International Union raised more money than most chemical firms did, and supported only Democratic candidates. The International Chemical Workers Union

Chemical company PACs gave most of their support to House candidates in 1980

			CONTRIBUTIONS TO CANDIDATES					
			Presidential		Senate		House	
Company	Receipts	Disbursements	Democrat	Republican	Democrat	Republican	Democrat	Republican
Dow Chemical	$337,831	$333,759	–	$1000	$10,350	$89,050	$43,050	$114,325
U.S. Steel	180,171	183,906	$2000	—	13,500	29,900	33,525	49,010
Monsanto	109,302	105,020	1500	1015	7,000	11,528	16,075	19,960
FMC	106,507	98,475	500	1640	11,100	17,975	26,290	36,220
Diamond Shamrock	79,504	74,358	2000	6200	3,950	15,750	5,400	25,450
B. F. Goodrich	62,576	59,549	1000	1000	3,850	15,300	5,450	22,900
Akzona	54,319	46,487	—	—	1,000	11,000	1,600	32,850
American Cyanamid	52,538	60,397	—	—	4,000	16,850	4,650	32,547
Eastman Kodak	41,597	26,138	—	5000	1,600	5,000	2,000	12,450
Union Carbide	40,877	40,644	—	—	1,500	6,500	6,650	14,850
Allied Corp.	39,785	36,218	—	—	4,150	9,200	3,200	11,300
NL Industries	39,745	38,050	—	500	4,000	8,000	7,250	13,700
Celanese	30,422	31,075	—	—	4,000	3,500	8,775	14,500
Oil, Chemical & Atomic Workers International Union	58,970	63,514	250	—	11,344	—	11,877	—
International Chemical Workers Union	18,524	20,178	800	—	4,725	600	8,350	200

Source: Federal Election Committee

had a PAC as well, but supported Democrats and Republicans.

Action on the 1982 election has begun already, but FEC has little data on what is being done at this point by PACs. Although the amount of total spending is likely to be smaller this year because it isn't a Presidential election, it's a safe bet that the spending for House and Senate races will exceed that put out during 1980. □

Industry group supports cancer policy rethinking

The American Industrial Health Council can only be pleased that the Occupational Safety & Health Administration is reconsidering its generic cancer policy (C&EN, Jan. 11, page 20). And, in comments filed with the agency, the council says that it would welcome, during that review period, the stay OSHA has proposed on the policy's listing requirements.

These requirements specify that OSHA must issue annually a candidate list of substances which may be considered for possible regulation. Based on minimal scientific review, OSHA then can classify the substances as category I (best evidence of potential carcinogenicity) or category II (suggestive evidence). The policy also requires OSHA to publish at least every six months two priority lists: a list of 10 candidates for rule making as potential category I carcinogens and a list of about 10 candidates for category II rule making.

So far OSHA has not published either priority list, although it did publish a candidate list of about 200 substances in August 1980.

AIHC, an industry organization with about 140 member companies and about 60 cooperating trade associations, has challenged the cancer policy in court. It says it supports a stay of the listing requirements because "while of little utility in setting realistic priorities for OSHA regulation, these lists can be expected to lead to unwarranted concerns by the public and possible disruptions in the workplace as workers draw erroneous conclusions from the listing of particular substances. They also could become commercial blacklists and as such could have a serious adverse impact in the marketplace."

The council stresses that it agrees that OSHA should set priorities but says such decisions should be based upon sound scientific evaluation of all available evidence. □

Federal Alert—
new legislation

This C&EN report highlights legislation introduced between Feb. 1 and Feb. 28. Senate and House bills are listed under subject area by bill number, primary sponsor, and committee(s) to which referred.

SENATE

Agriculture. S. 2122—Helms (R.-N.C.). Repeals requirements that USDA must hold a public hearing before prohibiting or restricting the movement of certain articles within the U.S. to prevent the spread of injurious plant diseases or insect pests; referred to Agriculture, Nutrition & Forestry.

Chemical warfare. S. 2078—Hart (D.-Colo.). Prohibits expenditure of any funds from the fiscal 1983 defense budget for the production or deployment of binary chemical weapons; referred to Armed Services.

Congress. S. 2008—Quayle (R.-Ind.). Establishes mechanisms for two-year Congressional budget approval process; referred to Budget, Governmental Affairs.

Copyright. S. 2044—Cochran (R.-Miss.). Amends the copyright law to exclude from the definition of a "work made for hire" one composed as a contribution to a collective work, such as magazine articles and short stories, or to an instructional text; referred to Judiciary.

Drugs. S. 2130—Kassebaum (R.-Kan.). Provides financial incentives for the development of so-called "orphan" drugs, eases regulatory requirements governing their approval; referred to Labor & Human Resources.

Energy. S. 2074—Johnston (D.-La.). Provides for the phased elimination of price controls on all categories of natural gas, with complete decontrol taking effect on Jan. 1, 1985; referred to Energy & Natural Resources.

Environment. S. 2131—Moynihan (D.-N.Y.). Establishes procedures for the identification, designation of special protection areas within sole source aquifer regions; development, implementation of site-specific management plans to protect the areas; referred to Environment & Public Works.

Trade. S. 2071—Heinz (R.-Pa.). Provides the President with additional, discretionary authority to seek removal of nontariff barriers to trade; referred to finance.

HOUSE

Chemical warfare. H.R. 5608—Moffett (D.-Conn.). Prohibits the production of binary chemical weapons in the U.S., calls on President to enter into negotiations with U.S.S.R. immediately for a mutual, verifiable limitation on the production and stockpiling of such weapons; referred to Armed Services, Foreign Affairs.

Energy. H.R. 5404—Brown (R.-Colo.). Abolishes Synthetic Fuels Corp.; referred to Banking, Finance & Urban Affairs, Energy & Commerce.

H.R. 5441—Glickman (D.-Kan.). Amends the U.S. Synthetic Fuels Corp. Act to include biomass within the definition of synthetic fuels; referred to Banking, Finance & Urban Affairs, Energy & Commerce.

H.R. 5497—Moorhead (R.-Calif.). Repeals Department of Energy's building energy performance standards, industrial energy reporting regulations, and appliance efficiency standards; referred to Banking, Finance & Urban Affairs, Energy & Commerce.

H. Res. 371—Dingell (D.-Mich.). Expresses the sense of the House of Representatives that the Federal Energy Regulatory Commission should take no action to accelerate the decontrol of wellhead natural gas prices; referred to Energy & Commerce.

Environment. H.R. 5055—Rahall (D.-W.Va.). Requires 10-year federal acid precipitation study to be completed in five years, calls for examination of usefulness of precombustion treatment of fuels in reducing sulfur dioxide and nitrogen oxide emissions; referred to Energy & Commerce, Science & Technology.

H.R. 5555—Waxman (D.-Calif.). Amends Clean Air Act to require listing of 37 pollutants as hazardous, unless found not to be within one year; creates 31-state acid region in which sulfur dioxide emission must be reduced 10 million tons over next decade; referred to Energy & Commerce.

H.R. 5562—Carney (R.-N.Y.). Companion bill to S. 2131 above; referred to Energy & Commerce.

Food. H.R. 5491—Gore (D.-Tenn.). Amends food laws to define safe as a "reasonable certainty that the risks of a substance under the intended conditions of use are insignificant," permits FDA to phase substances out of food over a period of up to five years, authorizes development of external peer review mechanisms for food safety decisions; referred to Energy & Commerce.

Innovation. H.R. 5444—Hammerschmidt (R.-Ark.). Requires federal agencies with an R&D budget of more than $1 million to set aside 3% of that budget for a three-phase small business innovation research program; referred to Small Business.

Patents. H.R. 5602—Kastenmeier (D.-Wis.). Sets fees for processing and maintaining patents and trademarks at level sufficient to recover costs; referred to Judiciary.

Taxes. H.R. 5517—Evans (R.-Iowa). Denies a tax deduction for interest on indebtedness incurred to acquire corporations, if the President determines that the use of debt for such purposes should be discouraged; referred to Ways & Means.

Trade. H.R. 5457—Brodhead (D.-Mich.). Companion bill to S. 2071 above; referred to Ways & Means.

H.R. 5604—McDade (R.-Pa.). Encourages exports by facilitating formation and operation of export trading companies, export trade associations, the general expansion of export trade services; referred to Foreign Affairs, Banking, Finance & Urban Affairs, Judiciary.

NOTE

ONLY THE FOLLOWING PAGES OF THIS

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Cover 1, p. 1, 22-25.

MIT's Whitehead Institute spotlights debate on academic goals and values Page 7

Chemical & Engineering NEWS

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Peer Review

Is there a better way to fund research?

Page 32

March 15, 1982
Volume 60, Number 11
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Chemical & Engineering NEWS

2 Letters

Concentrates
13 Business
16 Government
21 Science/Technology

The Departments
48 Awards
56 Newscripts

News of the Week

- ***The U.S. chemical industry*** *cutback in capital spending is worsening.* ***Page 4***
- ***Henry H. Reichhold retires*** *as chief executive officer of Reichhold Chemicals.* ***Page 5***
- ***High-solids coatings benefit*** *from tightened EPA air quality standards on solvent coatings emissions.* ***Page 5***
- ***Group asks Congress to force EPA*** *to limit emissions of hazardous air pollutants.* ***Page 5***
- ***Task force charges*** *that export control laws hamper university research conducted for the Department of Defense.* ***Page 6***
- ***Mobay Chemical discontinues*** *its ABS plastics business.* ***Page 6***

News Focus

- ***MIT's new biomedical research institute*** *is the focus of a debate on academic values and conflict of interest.* ***Page 7***

Business

- ***Henkel's William Spliethoff*** *honored for early work with commercial development.* ***Page 14***

Government

- ***Congress debates proposed 1983 budget;*** *Republicans and Democrats join forces to try to lower deficit.* ***Page 18***
- ***CMA calls for decontrol*** *of natural gas prices as soon as possible.* ***Page 20***

Technology

- ***Development of electrolytic cell membranes*** *spurred by chlor-alkali industry need to save energy, control pollution.* ***Page 22***
- ***Solar energy*** *as an economical source of industrial process heat is not yet feasible but tests are continuing.* ***Page 26***
- ***Solar power plant*** *designed to produce electricity on a commercial scale will begin operating early next month.* ***Page 27***

Science

- ***Laser technique*** *separates low levels of rare-earth elements for analysis in evaluating nuclear weapons performance.* ***Page 30***

Special Report

Peer review—*is it the best means of choosing the highest quality research for financial support? Most studies indicate the answer is yes.* ***Page 32***

Books

- ***"Refusenik: Trapped in the Soviet System"*** *recounts the struggle of a prominent physicist to emigrate to Israel.* ***Page 44***

ACS News

- ***ACS members offered expanded discount rates*** *on Hertz car rentals.* ***Page 46***

Electrolytic cell membrane development surges

Perfluorinated membranes offer chlor-alkali producers energy savings and less pollution; firms vie for share of growing market

Stephen C. Stinson
C&EN, New York

Energy savings and pollution control needs of the chlor-alkali industry have teamed up with accelerated competition among electrolytic cell membrane producers to spark development of new, more efficient membranes. Competitive intensity also has led membrane producers to disclose more of their technology than ever before, in efforts to persuade prospective customers of their expertise.

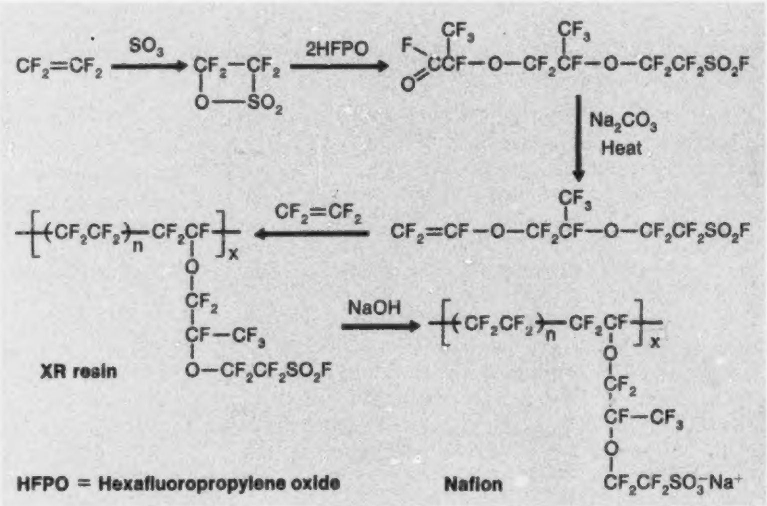
Increased membrane production capacity to meet the needs of the chlor-alkali industry may mean increased supplies of membranes at competitive prices for development of such other applications as hydrogen production, fuel cells, energy storage systems, pollution control devices, and catalysts. Some of these other applications may result from work of academic chemists, attracted by the unique ion and fluid transport properties of these membranes.

The membranes are perfluorinated ionomer membranes containing sulfonate and/or carboxylate groups in the resin. These anionic groups almost completely inhibit transport of hydroxide ions from the cathode compartment of a chlor-alkali cell, while letting current flow in the form of sodium ions. The result is production of caustic that is purer and more concentated than that from diaphragm cells. And the membrane cells avoid potential pollution from mercury cells (C&EN, March 20, 1978, page 20).

New developments in perfluorinated membranes, coupled with companies' increased willingness to talk about their materials, led the American Chemical Society's Division of Polymer Chemistry to organize a workshop on the subject that was held recently in Lake Buena Vista, Fla.

The four companies now jockeying for position in the worldwide chlor-alkali cell membrane market are Asahi Chemical Industry, Tokyo; Asahi Glass Co., Yokohama; Du Pont, Wilmington, Del.; and Tokuyama Soda Co., Tokyo. The stakes are high. Paul Henstridge, membrane cell business manager at Imperial Chemical Industries, a chlor-alkali cell maker, estimates that chlor-alkali producers in noncommunist countries will add 22 billion lb per year of new chlorine capacity by 1990. If all of this capacity were membrane cells, which now seem the favored route, these plants would need 3.3 million to 4.4 million sq ft of membrane, worth \$13 million to \$18 million at current prices. Also, because membranes may last only one to two years, membrane produc-

Du Pont Nafion membranes were the first of their kind...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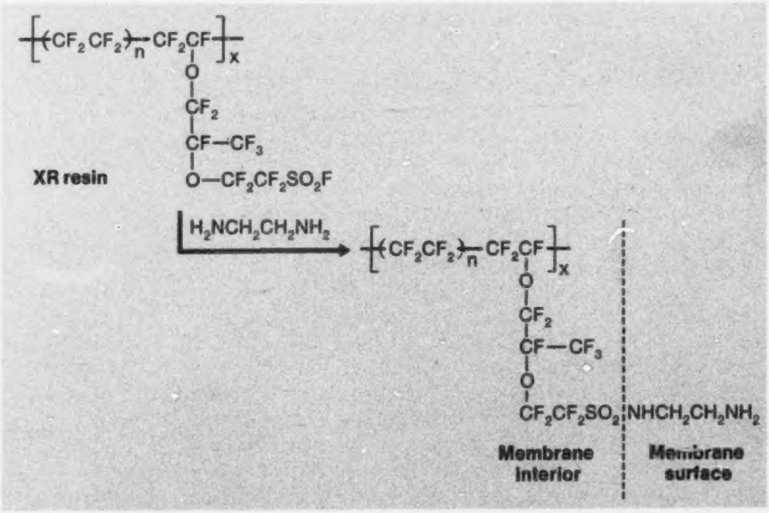
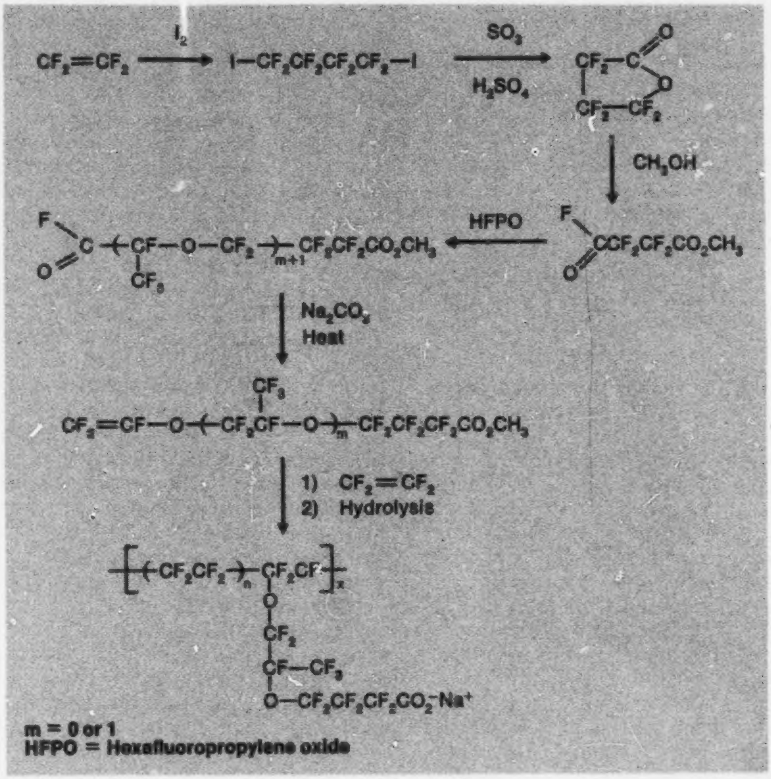
SO3
CF2—CF2
O—SO2
2HFPO
F
CF3
CF3
CCF—O—CF2CF—O—CF2CF2SO2F
O
Na2CO3
Heat
CF2=CF—O—CF2CF—O—CF2CF2SO2F
CF2=CF2
—[(CF2CF2)n—CF2CF]x—
O
CF2
CF—CF3
O—CF2CF2SO2F
XR resin
NaOH
CF2CF2SO3⁻Na⁺
Nafion
HFPO = Hexafluoropropylene oxide

...which sometimes got a surface treatment


—[(CF2CF2)n—CF2CF]x—
O
CF2
CF—CF3
O—CF2CF2SO2F
XR resin
H2NCH2CH2NH2
CF2CF2SO2 NHCH2CH2NH2
Membrane interior
Membrane surface

Asahi Glass developed monomers for carboxylate resins


m = 0 or 1
HFPO = Hexafluoropropylene oxide

ers would see a lot of repeat orders. Ultimately, with conversion of all chlor-alkali production to membrane cells in noncommunist countries, the annual market may be $250 million.

Roger A. Smith of Du Pont described the company's newest entry for the chlor-alkali market, Nafion 901. The new membrane has a perfluorocarboxylate resin layer perhaps 70 μm thick, laminated to a perfluorosulfonate membrane 100 to 300 μm thick, with the whole assembly probably reinforced by a woven polytetrafluoroethylene backing. This two-layer membrane, with the carboxylate layer facing the cathode (caustic) compartment, is intended to retain the high conductivity of perfluorosulfonate while improving current efficiency by impeding back migration of hydroxide into the anode compartment. The perfluorinated resins make the membranes resistant to high cell operating temperatures and the degrading effects of chlorine and caustic.

Du Pont developed the first perfluorinated ionomer membranes about 20 years ago during work with GE on a fuel cell. The company copolymerizes tetrafluoroethylene with a perfluorovinyl ether sulfonyl fluoride. Production of the sulfonate monomer begins with reaction of tetrafluoroethylene with sulfur trioxide to form 2-hydroxyethanesulfonic acid sultone. The sultone rearranges to fluorocarbonylmethanesulfonyl fluoride, which Du Pont reacts with 2 moles of hexafluoropropylene oxide to yield a compound with a terminal 1-fluorocarbonyltrifluoroethoxy group. This group loses carbonyl fluoride on heating with such catalysts as sodium carbonate to give the vinyl monomer. Du Pont converts the sulfonyl fluoride form of the copolymer resin to a more thermoplastic sulfonyl chloride for processing, then hydrolyzes with potassium hydroxide solution to the sulfonate form.

Though sodium and water transport and conductivity are high for plain sulfonate membranes, back migration of hydroxide is excessive. Working on the idea that high membrane water content lowered the barrier to hydroxide ions, Du Pont scientists developed membranes with a higher equivalent weight layer facing the cathode compartment, then added a surface treatment with ethylenediamine. Reaction of the cathode-side surface in the sulfonyl fluoride form with ethylenediamine produced *N*-β-aminoethylsulfonamide groups facing that side. These groups were more weakly acidic than sulfonic acid groups and thus retained less water. But the lifetimes of surface-treated membranes were too short in chlor-alkali cells.

Du Pont has signed an agreement with Asahi Glass to cross-license patents, and it may be that Du Pont's carboxylate layer is made according to Asahi Glass technology. Maomi Seko of Asahi Chemical has criticized the approach involving formation of a carboxylate layer by lamination, saying that adding the layer decreases electrical conductivity excessively. Du Pont scientists may have opted to make the membrane more robust and longer-lived by lamination, thus saving frequent replacement costs to users.

Asahi Chemical's Seko, in describing the firm's membrane chemistry, says that in addition to favoring a surface carboxylation treatment for sulfonate ionomer membranes, Asahi Chemical scientists also worked to develop a lower-molecular-weight comonomer for tetrafluoroethylene to lower equivalent weights of copolymer resins. His company devised syntheses of a series of terminal perfluorovinyloxyalkane-sulfonyl fluorides and terminal perfluoro(α-methyl-β-vinyloxy)ethoxyalkanesulfonyl fluorides for this purpose.

Asahi Chemical makes the cathode side of the tetrafluoroethylene copolymer membrane resistant to hydroxide back migration by surface oxidation of sulfonyl to carboxylate groups. Seko says his firm converts sulfonyl fluoride to sulfonyl chloride groups, reduces surface sulfonyl chloride to sulfenic acid groups, then oxididizes sulfenic acid to carboxylate groups. The resulting carboxylate layer of the membrane is 2 to 10 μm thick, he says.

The Tokuyama Soda approach also involves surface oxidation to carboxylate groups, according to senior chief researcher Toshikatsu Sata. The company begins with Du Pont Nafion in the sulfonyl chloride form, coats the surface with an alcohol, and subjects the alcohol-wetted surface to air oxidation. This is also the technique used by Asahi Chemical until 1976, when the company turned from Nafion to membranes made from tetrafluoroethylene and its own comonomers.

Asahi Glass departs from technology of the other three companies in producing an all-carboxylate ionomer membrane. Hiroshi Ukihashi says

Asahi Chemical leads in membrane chlor-alkali capacity

Thousands of metric tons per year	Caustic capacity[a]	Market share %
Asahi Chemical	520	69%
Diamond Shamrock[b]	121	16
Asahi Glass	42	6
Hooker & Uhde[b]	42	6
Tokuyama Soda	14	2
Ionics & Celleco[b]	11	1
TOTAL	750	100%

a Installed or under construction. b Firms using Du Pont Nafion membranes. Source: Asahi Chemical Industry

that his firm has developed perfluorocarboxylate monomers for copolymerization with tetrafluoroethylene. The firm treats tetrafluoroethylene with iodine to give 1,4-diiodooctafluorobutane, which reacts with fuming sulfuric acid to form tetrafluorobutyrolactone. Methanol converts the lactone to tetrafluorosuccinic acid monomethyl ester acid fluoride. Reaction of the acid fluoride with 1 or 2 moles of hexafluoropropylene oxide yields compounds with terminal fluorocarbonyl groups. After heating with sodium carbonate, these monomers are copolymerized with tetrafluoroethylene. Alkaline hydrolysis of the methyl ester groups produces membrane resins. Ukihashi says the methyl ester form of the resin does not decompose at temperatures below 320 °C and is melt-processable into membranes by injection molding or extrusion at melt temperatures of 200 to 250 °C.

One striking feature of industry presentations on all four membrane types was the routine reporting of current efficiencies of 95% or more. Seko of Asahi Chemical reported 96% for its membrane; Ukihashi of Asahi Glass, 97% for its Flemion membranes; Smith of Du Pont, 94.5 to 96.5% for Nafion 901; and Sata of Tokuyama Soda, 93 to 95% for its Neosepta-F membranes. This compared with 50% for unmodified Nafion, Sata said.

These high current efficiencies translate into lower power consumption per unit of caustic produced. For example, Seko of Asahi Chemical reported 2100 kWh per metric ton at 3 kiloamperes (kamp) per square meter and 1950 kWh at 2 kamp per sq m, while Smith of Du Pont reported 2400 to 2600 kWh at 3 kamp per sq m and 2200 kWh at 2 kamp per sq m. These figures compare with 2800 kWh for the mercury cell and 2180 kWh for the diaphragm cell. Thus the new membrane materials have tipped the balance away from diaphragm cells on the basis of power consumption alone, without even considering the low concentrations and high sodium chloride contents of diaphragm cell caustic solution product.

The decreased permeability of the four membrane types to hydroxide ions also has increased the maximum caustic solution concentrations tolerable for high current efficiencies. Three of the four firms have developed membranes for 20% caustic solution and a higher concentration, depending on user needs. The 20% membranes have lower equivalent weights than membrane resins for higher concentrations. Asahi Chemical has membranes for 21% and 30% caustic; Asahi Glass has Flemion membranes for 20% and 35 to 40% caustic, as well as a membrane designed especially for 35% potassium hydroxide; Du Pont's Nafion 901 produces 33% caustic; and Tokuyama Soda's two Neosepta-F membranes are for 20% and 27% caustic. These maximum caustic concentrations compare with 28% achieved by membrane cells of only four years ago.

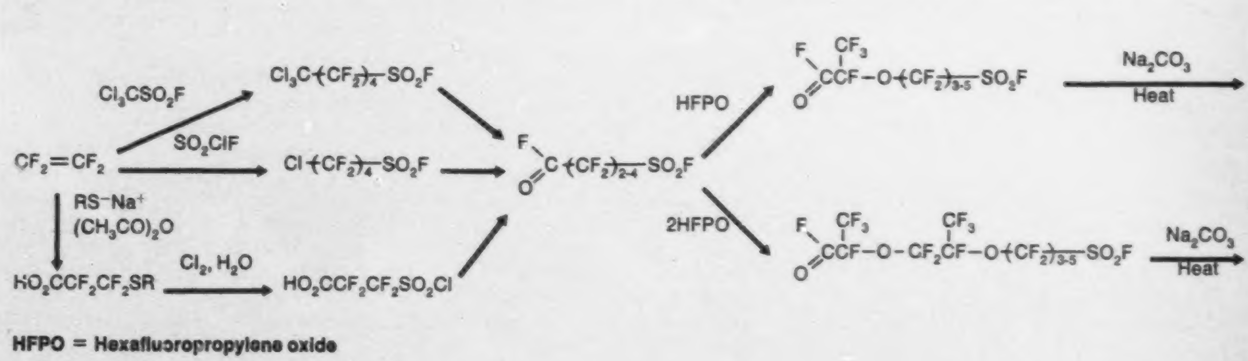
For the future, even further increases in current efficiency as well as reductions in cell volume may come from use of perfluorinated ionomer membranes as solid polymer electrolytes. In such cells, the polymer itself is the only electrolyte. Both surfaces are coated with metal particles to act as current collectors and as anode and cathode. Companies working on solid polymer electrolyte technology include Asahi Glass and Oronzio de Nora Impianti Elettrochimici, Milan, Italy. De Nora has signed an agreement with Dow Chemical, Midland, Mich., to develop such technology (C&EN, June 1, 1981, page 19).

Asahi Glass has reported producing 35% caustic in a solid polymer electrolyte cell at 1950 kWh per metric ton of caustic at 2 kamp per sq m and 2140 kWh at 4 kamp per sq m. De Nora has produced 28 to 30% caustic at 2200 kWh per metric ton and 3.3 kamp per sq m.

As Seko of Asahi Chemical points out, there is now 750,000 metric tons per year of caustic capacity based on membrane cells either installed or under construction worldwide, but none in the U.S. The first such U.S. plant may be the 200 metric-ton-per-day expansion by Vulcan Materials Co., at its Wichita, Kan., plant, scheduled to come on stream in 1983 with Nafion membranes.

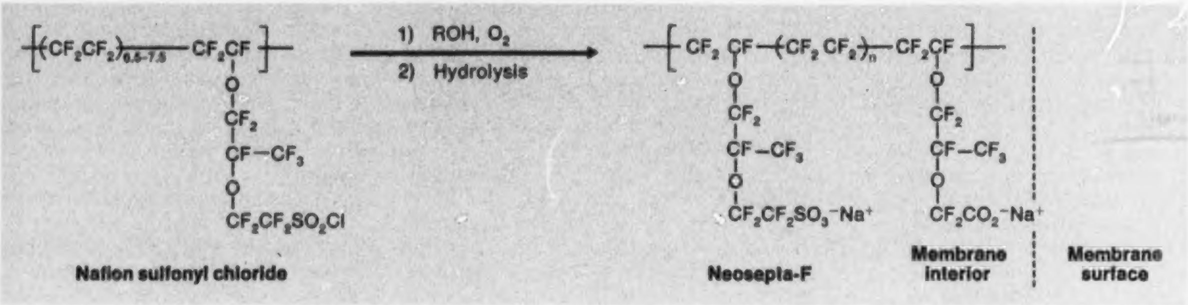
Beyond uses in the chlor-alkali industry, there are specialty applications for perfluorinated ionomer membranes in other electrolytes and in fuel cells. As Anthony B. LaConti of GE, Wilmington, Mass., points out, a GE fuel cell generated electricity from a hydrogen-oxygen reaction in the Gemini space missions;

Asahi Chemical monomers shorten side-chain lengths to lower copolymer equivalent weights



HFPO = Hexafluoropropylene oxide

Tokuyama Soda oxidizes Nafion membrane surfaces



and GE and other firms make water electrolyzers to generate oxygen aboard spacecraft and submarines, as well as hydrogen for chromatographs.

Nevertheless, the feasibility of such large-scale applications as hydrogen fuel or feedstock, combined electrolyzer-fuel cells as load levelers at electric power plants, or batteries for other purposes will be limited by the high cost of membranes. Du Pont's price for Nafion 901 is $460 per sq m. The three Japanese firms won't reveal their prices, but they are probably about the same. To cover high capital investment costs at these prices, water electrolyzers would have to run for long periods at the very high current densities of 10 to 20 kamp per sq m, a feat that seems beyond present membranes. Smith of Du Pont says that Nafion 901 membrane lifetimes might be measured in years as opposed to present one- to two-year lifetimes in the chlor-alkali industry. Membranes for large-scale hydrogen production would have to run at least five years.

Any electrolytic or fuel cell process would have to compete with alternative systems that do not use membranes. Such competition is possible in the chlor-alkali industry, because there is no other way to make chlorine and caustic than by electrolysis, and membrane cells clearly have emerged as superior to other cells. There is no such limited number of candidates for high-capacity batteries, and hydrogen is available at less cost from natural gas.

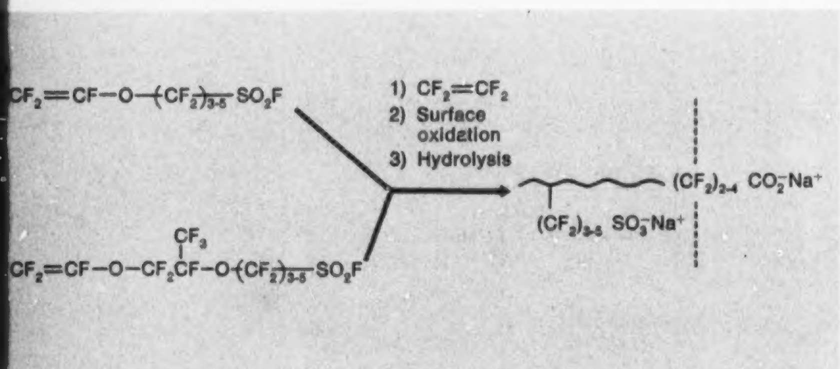
In a review of perfluorinated ionomer applications, chemistry professor Brian Kipling of the University of Calgary, Alta., noted that these membranes have been used to treat metal plating wastes, to catalyze organic chemical reactions, and to dry gases. Kipling cited work at Du Pont to demonstrate that chromium plating wastes with small amounts of iron, copper, and nickel could be treated to recover chromic acid for reuse. Lead anodes oxidize spent chromium(III) to chromium(VI), while other cations migrate through the membrane into the cathode compartment. The membrane inhibits migration of unwanted anions from the cathode into the anode compartment.

Another method Kipling cites for use in plating wastes is Donnan dialysis. In the Donnan principle, a concentrated solution of, for example, sodium chloride or sulfuric acid is separated by a membrane from a dilute solution of cations. Sodium or hydrogen ions migrate into the solution to be treated, matched by an equal number of equivalents of heavy metal cations that migrate out of the treated water. The resulting concentration of heavy metal cations produces a smaller volume of solution to be treated by other methods like precipitation.

In catalysis research, Kipling notes that organic chemistry professor George A. Olah had used the sulfonic acid form of Nafion at the University of Southern California, Los Angeles, to catalyze Friedel-Crafts reactions at relatively low temperatures.

Chemistry professor William M. Risen Jr. of Brown University, Providence, R.I., uses membranes in his work to catalyze gas-phase reactions. In one experiment, he soaked Nafion membranes in platinum(II) solutions, then warmed the membranes to dry them somewhat. He suggested that water removal may produce vacant coordination sites about platinum, making it coordinately unsaturated and a favorable acceptor for gas molecules. On passing carbon monoxide through the membrane, he observed production of carbon dioxide and hydrogen. In synthesis gas plants, this shift reaction is carried out by other means to produce hydrogen.

For gas drying, Kipling says that Perma Pure Products, Oceanport, N.J., makes units for this use. Moist gas flows in one direction through a Nafion tube, while a dry purge gas flows in the opposite direction in an outer jacket. The removal of water from the moist gas is based on the relatively faster transport of water than other gas molecules through Nafion. □



The crisis in European plastics
Page 13

Chemical & Engineering NEWS

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Page 41

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Chemical & Engineering NEWS

Cover: Photo by C&EN's Ward Worthy

4 Letters
7 Editor's Page

Concentrates

29 Business
33 Government
36 Science/Technology

The Departments

56 New Products
94 ACS News
96 People
110 Newscripts

News of the Week

- ***The Environmental Protection Agency*** *has aroused the ire of environmental groups in recent actions concerning disposal of hazardous wastes, lowering requirements for reporting by industry.* ***Page 8***
- ***Prospects for early recovery*** *from the recession dim as January production volume figures show a further drop and price discounting of many basic chemicals and polymers continues.* ***Page 9***
- ***Most powerful pulsed, superconducting magnet ever built,*** *according to Argonne National Laboratory, has been tested in preparation for testing cables for coils or future magnetic fusion reactors.* ***Page 9***
- ***Space shuttle*** Columbia, *scheduled to begin its third mission this week, will conduct experiments on micrometeorites, effect of weightlessness on plant growth, polarization of x-rays from solar flares.* ***Page 9***
- ***Stauffer Chemical will raze*** *its 140 million lb-per-year polyvinyl chloride plant in Long Beach, Calif., after failing to find a buyer; next to go may be its South Carolina fabrication plant.* ***Page 10***
- ***Procter & Gamble will enter the pharmaceuticals business*** *if its $371 million purchase of MortonNorwich's drug operations, including facilities in Mexico and Colombia, gets government approval.* ***Page 10***

News Focus

- ***Western European thermoplastics producers*** *are suffering heavy losses and the future offers only fiercer competition from the Middle East and Canada.* ***Page 13***

Business

- ***Naval stores*** *are as recession-hit as the rest of the industry but some products' inventories are low.* ***Page 30***

Government

- ***Federal government funding*** *for chemical R&D in fiscal 1983 will be about the same as in 1982, ACS study shows.* ***Page 34***

Science

- ***Cornell University scientist's claim*** *that use of sludge for fertilizer is harmful rebutted by other agriculturalists.* ***Page 38***

Instrumentation '82

"User friendly" *is the catchword describing today's focus of the analytical instrumentation industry displaying its wares at the Pittsburgh Conference.* ***Page 41***

Plastics enter crisis in Western Europe

A much larger industry than already troubled European fibers, the big thermoplastics are floating in a sea of red ink and worse competition is on the way from Canada and the Middle East

Dermot A. O'Sullivan
C&EN, London

In a 400-year-old English play, a Danish prince rues the "slings and arrows of outrageous fortune" and mulls those famous alternatives for extreme action—to be or not to be. That's about the current predicament in a critically important part of the European chemical industry, the five largest-volume thermoplastics: high-density and low-density polyethylene, polypropylene, polystyrene, and polyvinyl chloride.

Like Hamlet, top management in dozens of European chemical companies are facing a terrible choice as the storm over plastics closes in. Their words aren't Shakespeare's, but the meaning is just as dramatic. Should they hang on in the hope of being able to turn the business around, even in the face of an almost certain continual financial drain? Or should they cut their losses and pull out, with all the social and political trauma that would bring?

Practically all thermoplastics producers are in deep trouble. Production costs keep rising. Yet the vast overcapacities hanging over the market are keeping a lid on prices.

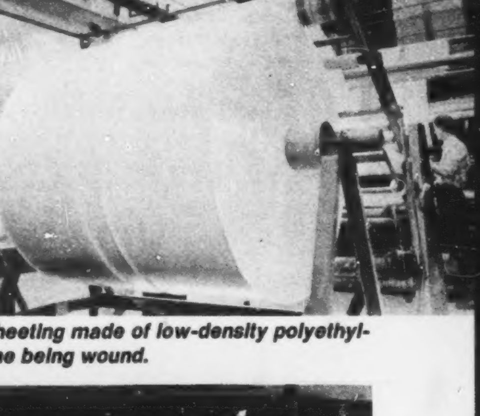
"Absolutely disastrous" is how John Harvey-Jones, chairman-elect of the U.K.'s Imperial Chemical Industries sums up the price situation during this past year.

Rolf Sammet, chairman of West Germany's Hoechst, estimated earlier this month that European producers of bulk thermoplastics chalked up a cumulative loss of some $2 billion last year. Paolo Morrione, who has taken over as head of Montepolimeri, the plastics arm of Italy's Montedison, agrees with Sammet's figure, adding that there is no way that anyone can be making money.

Following two years of falling sales and financial losses, the general contention is that the bottom has just about been reached, that demand will take an upturn, and, with it, prices. But the relief that such a change in fortune will engender could be comparatively shortlived. Supplies coming onto world markets from Canada and the Middle East in four or five years promise to spark another downward spiral for the West European producers.

It's a sad turn of events for the Europeans with their proud tradition in thermoplastic polymer technology. ICI pioneered development of low-density polyethylene (LDPE), for example. Next year is the 50th anniversary of the polymer's original discovery. The U.K. Plastics & Rubber Institute will hold a conference in London to mark the event. And the whole field of stereoregular, low-pressure polymerization of olefins—of which high-density polyethylene (HDPE) and polypropylene are the most commercially significant to date—rests on the fundamental studies of West Germany's Karl Ziegler and Italy's Giullio Natta for which they shared the 1963 Nobel Prize in Chemistry.

The present shaky market situation doesn't mean that a demise of the bulk thermoplastics in Western Europe is about to set in. Far from it. Plastics have become very much a part of daily life in Europe as elsewhere, and will continue to be so. Advantages stemming from their inherent physical properties and processability will ensure that they are here to stay. However, the heady days of double-digit annual growth that occurred in the 1950s and 1960s are gone forever, partly because the industry has become a mature one in its own right.



Sheeting made of low-density polyethylene being wound.

ICI's polyvinyl chloride plant in Wilhelmshaven is served by monomer plant in rear

Europeans try survival by shakeout

"Rationalization"—a more formal term for "shakeout"—in production and marketing of bulk thermoplastics in Western Europe offers the best hope of survival for the industry. Everyone sees need of it, everyone says it is bound to happen.

This is not mere idle musing. It is fair to assume that the overall profile of the industry will be different in five years from what it is today. Restructuring moves at individual company levels are gathering momentum.

Recently, for instance, the U.K.'s Imperial Chemical Industries unveiled plans to take over the polyvinyl chloride (PVC) operations of Switzerland's Lonza, the chemicals arm of Alusuisse. There are two plants, one in West Germany, the other in Switzerland itself, with combined annual nameplate capacity of 147 million lb split about equally between the two sites.

For ICI, the purchase will strengthen further its position as supplier of PVC to the continental European market. Last year, it brought on stream a 253 million lb-per-year plant at Wilhelmshaven, West Germany, together with an associated 660 million lb-per-year vinyl chloride facility there. The new PVC plant, with an older one in the U.K., puts ICI's total output capability at 880 million lb per year. The Lonza acquisition will move this up another 17% or so and provide ICI with special grades of the polymer that it doesn't now produce.

One of the early moves in European corporate reshuffling involving thermoplastics took place in France almost two years ago. Rhône-Poulenc relinquished sole ownership of a major part of its commercial chemicals business, including polymers. One result was establishment of a company named Chloé with three partners—Compagnie Française des Pétroles (Total) and Société Nationale Elf-Aquitaine, each with a 40.25% holding; and Rhône-Poulenc with 19.5%. Chloé takes its name from raw materials chlorine and ethylene.

Chloé has PVC plants at three French sites with combined nameplate capacity of some 880 million lb yearly. Meanwhile, Total and Elf-Aquitaine are partnered in ATO Chimie with plants making low-density polyethylene (LDPE), polypropylene, polystyrene, and PVC.

Italy is where the most intense revamping of production ownership is taking place right now. The key actors are Enoxy—the joint venture between Ente Nazionale Idrocarburi, Italy's state-owned hydrocarbons concern, and Occidental Petroleum—and Montedison's Montepolimeri. The process still is fluid. It will need government approval before the arrangements, now in detailed discussions, are completed.

Basically, it's expected that Enoxy will get the thermoplastics operations of several Italian companies—ANIC (an ENI subsidiary), Rumianca, Societa Chimica Ravenna, and Societa Industriale Resine. These, among them, have plants making all five thermoplastics, which will be transferred to Enoxy ownership. The exception will be the polypropylene activity of ANIC, to remain with that company.

Montepolimeri, meanwhile, expects to shift its LDPE operations to Enoxy. Plants at Brindisi, Ferrara, and Priolo have combined annual nameplate capacity of some 1 billion lb. Enoxy, therefore, would become sole Italian LDPE producer with nameplate capacity of more than 2 billion lb per year based on current figures. Montepolimeri would retain its PVC plants with their capacities totaling 1.1 billion lb per year.

Important as corporate mergings and reorganizations may be, more critical for Europeans is the need to reduce the very high levels of overcapacity in plants. There have been some moves in that direction, notably by BASF in Belgium and West Germany, and ATO, BP Chemicals, ICI, and Shell Chemicals in the U.K. In France, CdF Chimie has cut back on LDPE output and has converted one of its units to linear LDPE.

Overall, however, trimming of output capabilities hasn't been all that great. In fact, a number of companies have expansions planned or already under way. For example, at Antwerp, Polyolefins, jointly owned by Belgium's Petrofina and by Phillips Petroleum of the U.S., is expanding high-density polyethylene capacity (HDPE) from the present 264 million lb per year to 440 million lb. Work is expected to be completed before year's end. "We are confident in future demand and are going ahead," comments a Phillips spokesman.

Compounding the overcapacity problem, new production sites have appeared on the European scene this past year. Besides ICI's vinyl chloride and PVC operations in West Germany, Portugal's massive complex at Sines came into production. France's CdF Chimie has 28% interest in the venture, called Empresa de Polimeros de Sines. Portugal's National Petroleum Co. owns the balance. The complex has plants with annual capacity for 132 million lb of HDPE, 264 million lb of LDPE, and 110 million lb of polypropylene.

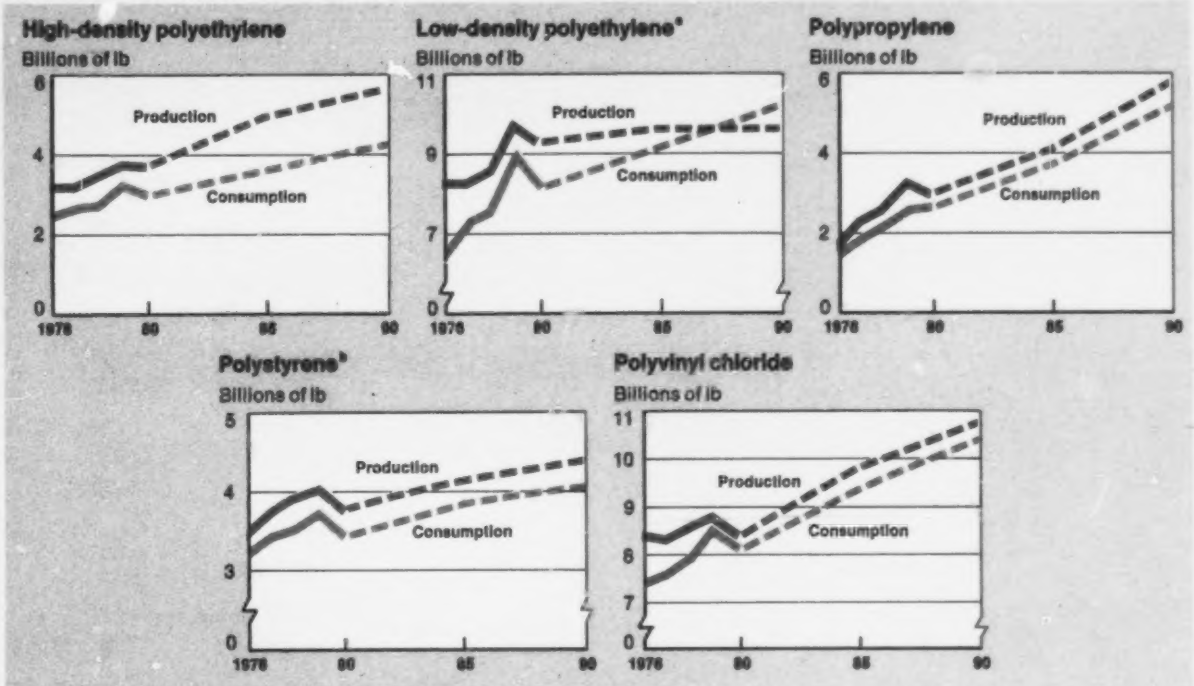
The burgeoning demand of previous years was spurred on both by substitution of such "traditional" materials as metals and glass by thermoplastics, as well as by innovation. The substitution element now has receded in importance as a promoter of growth, although it still exists. Special grades of polyvinyl chloride (PVC) are continuing to make inroads into aluminum and wood for the production of window frames, for example. Indeed, in West Germany, 40% or more of the window frames made there each year are based on PVC. Considerable potential also remains for plastics' use in automobile components, electric cable insulation, packaging, piping, and so forth.

The substitution factor, ironically, is proving to be something of a double-edged sword. Competition is occurring not only between plastics and other materials, but among the different members of the thermoplastics family. This makes forecasting future demand for individual polymers extremely difficult. Clouding the situation still more is the recent emergence of linear LDPE, which is being touted by its developers—CdF Chimie, Dow Chemical, and Union Carbide, to name but a few—as offering decided economic and performance advantages in packaging film and other uses.

Substitution and innovation, and the considerable investments these entail on the part of the converters, also have fallen victim to the general downturn in global economic activity spawned by the sharp rise in oil and energy costs since the mid-1970s. Gross domestic product has been severely depressed throughout Europe, with the European Economic Community as a whole showing negative values in 1975 and last year. Of the 10 member countries, 1981 GDP was below 1980's level for six—Belgium, West Germany, Italy, Luxembourg, the Netherlands, and the U.K. There was no change in Denmark. Only France, Greece, and Ireland registered growth, and that was marginal.

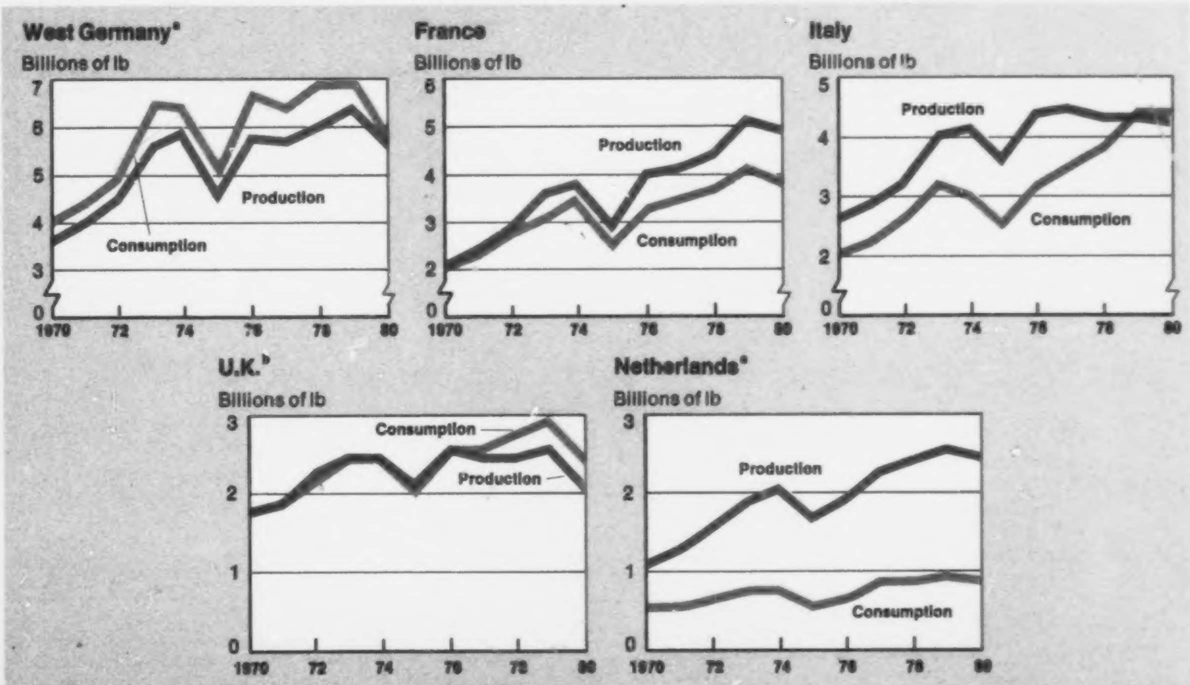
One result of low or nonexistent national growth is cuts in public spending. Large construction projects such as hospitals, schools, and roads have been stretched out, if not shelved entirely. Consequently, demand for thermoplastic products has suffered. On a broader front, in times of recession, especially when unemployment is high as it is throughout Europe, people think much more carefully before making purchases.

Fastest growing major thermoplastic in Europe is polypropylene . . .



a Includes linear LDPE production beginning 1980 and linear LDPE consumption beginning 1979.
b General purpose and high impact; excludes expendable grades.
Source: Chem Systems International

. . . whereas fastest growing producing countries are France and the Netherlands



a Excludes high-density polyethylene. b Excludes polystyrene. Note: Data include high-density polyethylene, low-density polyethylene, polypropylene, polystyrene, and polyvinyl chloride. Sources: West German Plastics Industry Association, French Association of Plastics Producers, British Plastics Federation, and industry estimates

Thermoplastics in Western Europe are marked by high nameplate capacities, many producers

	High-density polyethylene			Low-density polyethylene		
Millions of lb	Capacity	No. of plants	Producers	Capacity	No. of plants	Producers
Austria	—	—	—	517	1	BASF
Belgium	419	2	Dow Europe; Polyolefins[d]	1,419	2	BP Chemicals; Essochem
Finland	—	—	—	363	1	Pekema
France	647	3	BP Chemicals; Soc. Industrielle de Polyoléfines[g]; Solvay	2,255	5	ATO; CdF Chimie; Cie. Chimique de la Méditerranée[h]; Copenor[i]
West Germany	2112	5	Chemische Werke Huels; Hoechst: Rheinische Olefinwerke[h]; Ruhrchemie[j]; Wacker-Chemie	2,101	3	Erdölchemie[k]; Rheinische Olefinwerke[h] Ruhrchemie[j]
Greece	—	—	—	—	—	—
Italy	825	3	Enoxy; Montepolimeri; Solvay	2,176	2	Enoxy; Montepolimeri
Netherlands	330	1	DSM	1,725	3	Dow Europe; DSM; ICI
Norway	110	1	Norpolefin[l]	242	1	Norpolefin[l]
Portugal	132	1	Empresa de Polimeros de Sines[m]	264	1	Empresa de Polimeros de Sines[m]
Spain	407	3	Calatrava; Dow Europe; Tarragona Quimica[o]	1,115	3	Alcudia; Dow Europe; Union Explosivos Rio Tinto
Sweden	266	1	Unifos[q]	363	1	Unifos[q]
U.K.	308	1	BP Chemicals	1,188	4	BP Chemicals; ICI; Monsanto; Shell
TOTAL	**5606**	**21**		**13,728**	**27**	

a General-purpose and high-impact grades, excluding expandable grades. b Chemie Linz 50%, ÖMV 50%. c Solvay 75%, Österreichische Creditanstalt 25%. d Petrofina 50%, Phillips 50%. e Montpolimeri 50%, Petrofina 50%. f Solvay 75%, ICI 25%. g Chemische Werke Huels 50%, Cie. Française de Pétroles 25%, Cie. Française de Raffinage 25%. h BASF 50%, Shell 50%. i CdF Chimie 60%, Qatar Petroleum 40%. j Hoechst 66.6%, Union Rheinische Braunkohlen Kraftstoff 33.3%. k Bayer 50%, BP Chemicals 50%. l Norsk Hydro 33.3%, Saga

This, in turn, has cut into direct and indirect sales of plastic goods.

The downturn in European plastics consumption that has occurred during the past two years reflects these influences. Sales fell in 1980, and again last year. Compared to 1979, which was a fairly strong year of growth, West European consumption of the five largest-volume thermoplastics collectively slipped 6.3% to about 25.8 billion lb in 1980, the most recent year for which data generally are available.

LDPE fared worst, its use dropping 9.2% to 8.2 billion lb, with HDPE a close second at 8.1% down to 3.3 billion lb. Then followed general-purpose and high-impact grades of polystyrene, whose consumption dropped 6.4% to 3.5 billion lb, and PVC, whose use decreased 5.5% to 8.2 billion lb. Polypropylene bucked the trend, rising 2.7% to 2.8 billion lb.

West European thermoplastics producers gained some comfort in 1980 through a strong rise in the volume of exports. According to Stephen Harriman of London-based Technon UK, who has made a detailed study of the export markets, in 1980 shipments to countries outside Europe rose 12.4% from 1979, totaling 3.56 billion lb. Polystyrene led with a 44.4% increase to 462 million lb. Then followed polypropylene, up 32% to 506 million lb; HDPE, up nearly 29% to 717 million lb; and LDPE, up 12.5% to just over 1 billion lb. PVC was the only loser, with an export drop approaching 15% to about 845 million lb.

Looking ahead, the general consensus among producers is that annual growth in European consumption will be modest, assuming, of course, that a major economic upheaval doesn't occur. Polypropylene appears to have the brightest prospect, apart from brand new linear LDPE. Chem Systems International, a consultant firm, pegs polypropylene's average annual increase at 7% between 1980 and 1990, bringing overall local demand by 1990 to 10.3 billion lb.

For HDPE, an increase of 3.5% per year to 4.4 billion lb in 1990 is forecast. PVC's annual growth might be a more modest 2.5% annually to 10.5 billion lb, and that of general-purpose and high-impact polystyrene could be as low as 1.5% to 4.1 billion lb.

LDPE is something of an anomaly with a distinctly two-tier growth pattern in store. Demand for conventional material isn't expected to show any growth in Europe in the years immediately ahead and most likely will undergo a decline on a year-to-year basis. On the other hand, strong growth is foreseen for linear LDPE. Between 1980 and 1985, growth could be as high as 59% annually, Chem Systems believes, slackening to 11% per year for the balance of the decade.

"When it comes to making an

Polypropylene			Polystyrene[a]			Polyvinyl chloride		
Capacity	No. of plants	Producers	Capacity	No. of plants	Producers	Capacity	No. of plants	Producers
216	1	Petrachemie Schwechat[b]	—	—	—	132	1	Halvic Kunstoffwerke[c]
726	3	Amoco; Hercules; Montefina[e]	680	3	BASF; Dow Europe; Montefina[e]	715	2	BASF; Solvic[f]
—	—	—	22	1	Stymer	132	1	Pekema
816	5	ATO; BP Chemicals; Hoechst; Shell; Solvay	902	3	ATO; BP Chemicals; CdF Chimie	2,244	5	ATO; Chloé; PCUK; EMC; Solvic
858	3	Chemische Werke Huels; Hoechst; Rheinische Olefinwerke[j]	1694	2	BASF; Chemische Werke Huels	2,974	7	BASF; Chemische Werke Huels; Hoechst; ICI; Lonza; Solvay; Wacker Chemie
—	—	—	70	1	Dow Europe	110	1	Essochem
880	2	ANIC; Montepolimeri	803	4	Dow Europe; Enoxy; Mazzuchelli Celluloide; Montepolimeri	2,288	3	Enoxy; Montepolimeri Solvic
462	3	DSM; ICI; Shell	524	2	Dow Europe; Hoechst	792	2	DSM; Shell
132	1	Norpolefin[l]	—	—	—	165	1	Norsk Hydro
110	1	Empresa de Polimeros de Sines[m]	—	—	—	132	1	Companhia Industrial de Resinas Sinteticas[n]
198	2	Poular; Tarragona Quimica[p]	275	3	Arrahona; BASF; Dow Europe	781	3	Aiscondel Hispavic[f]; Rio Rodano[p]
123	1	Svenska Polystyren[r]	—	—	—	220	1	KemaNobel
660	2	ICI; Shell	297	3	Dow Europe; Monsanto; Shell	1,287	4	British Industrial Plastics; BP Chemicals; ICI; Norsk Hydro
5181	**24**		**5267**	**22**		**11,972**	**32**	

Petrokjemi 33.3%, Statoil 33.3%. m Companhia Nacional de Petroquimica 72%, CdF Chimie 28%. n Portuguese interests 50%, Mitsui 25%, Shin-Etsu 25%. o Union Explosivos Rio Tinto 55%, Hoechst 45%. p Rhône-Poulenc 50%, Union Explosivos Rio Tinto 50%. q KemaNobel 50%, Union Carbide 50%. r Chemische Werke Huels 50%, Johnson Group 50%. **Note:** Capacities as of year-end 1981.

LDPE forecast, the practice is to combine conventional and linear LDPE, thereby masking the fast rise of linear LDPE that will compensate for the slow decline of conventional LDPE," explains Françoise Pardos, a polymers marketing analyst based near Paris. Moreover, she adds, "definitions are increasingly blurred among HDPE, LDPE, and linear LDPE through coblending and the capability to switch production from one product to another in the newer plants, as well as the possibility of making linear LDPE in polypropylene plants."

In some measure, European thermoplastics producers are a victim of their past successes. The seemingly limitless consumer appetite for their products less than a decade ago fostered the installation of new and expanded units, even in the wake of the first oil crisis of 1973 and the succeeding economic repercussions. According to figures compiled by the Commission of the European Communities in Brussels, EEC capacity for making polypropylene in 1980 was more than double what it was in 1975. Capacity for the other polymers also was expanded, but to a lesser extent—LDPE 28%, HDPE 27%, polystyrene 19%, and PVC 14%.

In terms of nameplate capacities, the resulting figures are startlingly high for Western Europe as a whole. Conventional LDPE leads capacity totals with nearly 14 billion lb of annual output capability. Next comes PVC with almost 12 billion lb. For HDPE, polypropylene, and polystyrene, the values are in excess of 5 billion lb per year for each.

Admittedly, nameplate capacity values should be regarded with some skepticism. Some units that companies officially count are temporarily out of service, shut indefinitely, or permanently closed down. Nevertheless, the figures do provide some measure of the considerable investment that has taken place in the industry.

Those units now functioning operate at rates well below their maximum effective capacity, which generally is about 10% less than official nameplate capacity. The EC Commission survey puts the average capacity utilization rate for the EEC thermoplastics industry in 1980 in the profit-sapping range of 62 to 68%, in contrast to 75 to 85% in 1973.

Paul A. Ray of ICI Petrochemicals & Plastics division's strategic planning group cites capacity use rates of 81% for PVC, 79% for LDPE, 74% for polypropylene, 67% for HDPE, and 63% for polystyrene in Western Europe.

"It is relevant to look not only at the percentage 'occupacities' [effective capacity use rates], which for a capital-intensive industry are very bad, but at the absolute figures of spare capacities—around 9 billion lb in total," Ray says. "In terms of cap-

Low-density polyethylene was major thermoplastic exported from Europe in 1980

	Export markets for Western Europe's thermoplastics									
Millions of lb	Low-density polyethylene		High-density polyethylene		Polyvinyl chloride		Polypropylene		Polystyrene	
Africa	317.12	30.8%	281.86	39.3%	263.58	31.2%	99.18	19.6%	32.80	7.1%
Asia	118.40	11.5	78.89	11.0	81.10	9.6	130.04	25.7	79.46	17.2
Eastern Europe	139.00	13.5	123.36	17.2	134.32	15.9	83.49	16.5	204.67	44.3
Latin America	197.68	19.2	65.98	9.2	108.13	12.8	68.31	13.5	17.56	3.8
Middle East	251.22	24.4	111.88	15.6	239.92	28.4	118.91	23.5	127.51	27.6
Oceania	6.18	0.6	2.15	0.3	6.76	0.8	—	—	—	—
U.S. & Canada	—	—	53.07	7.4	10.58	1.3	6.07	1.2	—	—
TOTAL	**1029.60**	**100.0%**	**717.19**	**100.0%**	**844.79**	**100.0%**	**506.00**	**100.0%**	**462.00**	**100.0%**

Source: Tecnon (U.K.) Ltd.

U.S. plastics exports to Europe fell in 1981

Millions of lb	**1981[a]**	**1980**	**1979**	**1978**	**% change 1980–81**
Polyethylene, low and medium density					
To Western Europe	99.059	171.532	71.269	44.985	−42.25%
Total U.S. exports	966.437	1187.269	916.224	682.699	−18.60
Western Europe as % of total	10.25%	14.45%	7.78%	6.59%	
Polyethylene, high density					
To Western Europe	47.846	76.504	64.043	52.974	−37.46
Total U.S. exports	617.749	711.180	725.265	477.686	−13.14
Western Europe as % of total	7.75%	10.76%	11.59%	11.09%	
Polypropylene					
To Western Europe	32.078	72.189	39.646	16.394	−55.56
Total U.S. exports	633.758	849.880	802.123	326.569	−25.34
Western Europe as % of total	5.06%	8.50%	4.94%	5.02%	
Polystyrene					
To Western Europe	3.983	12.368	12.004	7.310	−67.80
Total U.S. exports	200.167	226.636	199.991	149.552	−11.68
Western Europe as % of total	1.99%	5.46%	6.00%	4.89%	
Polyvinyl chloride (compounded and uncompounded)					
To Western Europe	62.888	65.617	33.510	35.23[illegible]	−4.19
Total U.S. exports	470.162	481.812	372.069	271.204	−2.42
Western Europe as % of total	13.37%	13.62%	9.01%	12.99%	

a Estimate for 1981 based on first 10 months' figures. **Source:** U.S. Department of Commerce

ital at current prices, around $3 billion of assets were not earning a dime in 1980." The situation probably worsened last year.

Not surprisingly, top managements of practically all companies in the business are subjecting their operations to intense scrutiny. This already has led to some streamlining of their operations, including plant shutdowns. More will follow.

It's tempting to liken the current depressed state of West European thermoplastics to the more notorious poor performance of synthetic fibers there in the past few years. True, there are some similarities, but it is too simplistic an analogy. Fundamental differences would make a correction of the polymers problem much more difficult to achieve.

For one, there are many more companies (and more diverse ones at that) engaged in thermoplastics production than there are in fibers. In contrast to the dozen or so majors making synthetic fibers when troubles in that industry set in five or six years back, there are about twice that number in each of the bulk thermoplastics. Thermoplastics are simply a much bigger business with much more at stake for the industry.

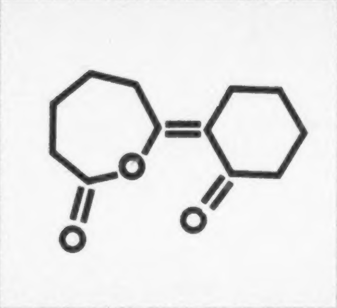
Linear low-density polyethylene and polypropylene hold promise of growth

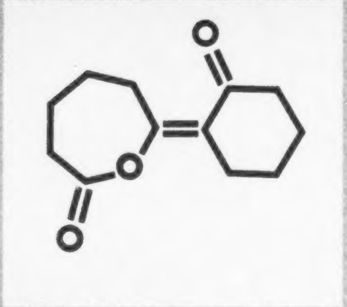
	% annual change			
	1976–80	1980–85	1985–90	1980–90
High-density polyethylene				
Production	4.0%	5.7%	2.4%	4.0%
Consumption	4.8	3.6	3.3	3.5
Net exports	1.2	−11.0	−0.6	−5.9
Low-density polyethylene[a]				
Production	2.6	−1.7	−0.2	−0.9
Consumption	5.4	−0.5	0.3	−0.1
Net exports	−8.5	−6.5	−9.7	−8.1
Linear low-density polyethylene				
Production	0.0	82.0	7.0	39.5
Consumption	0.0	58.5	10.8	32.5
Net exports	0.0	0.0	0.0	0.0

	% annual change			
	1976–80	1980–85	1985–90	1980–90
Polypropylene				
Production	15.3	6.0	7.2	6.6
Consumption	14.0	6.8	7.3	7.0
Net exports	40.6	−6.9	5.9	−0.7
Polystyrene				
Production	1.8	2.0	0.9	1.5
Consumption	1.7	2.0	1.0	1.5
Net exports	2.4	3.4	0.0	1.7
Polyvinyl chloride				
Production	0.1	3.1	1.9	2.5
Consumption	2.3	2.9	2.0	2.5
Net exports	−21.6	2.2	−1.6	0.3

a Excluding linear low-density polyethylene. **Source:** Chem Systems International

Z or E lactone?





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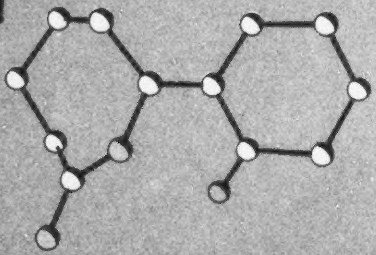

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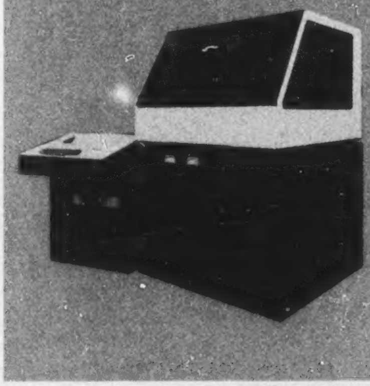

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*Jennings et al. Journal of Organic Chemistry, 1981, 46, 2589

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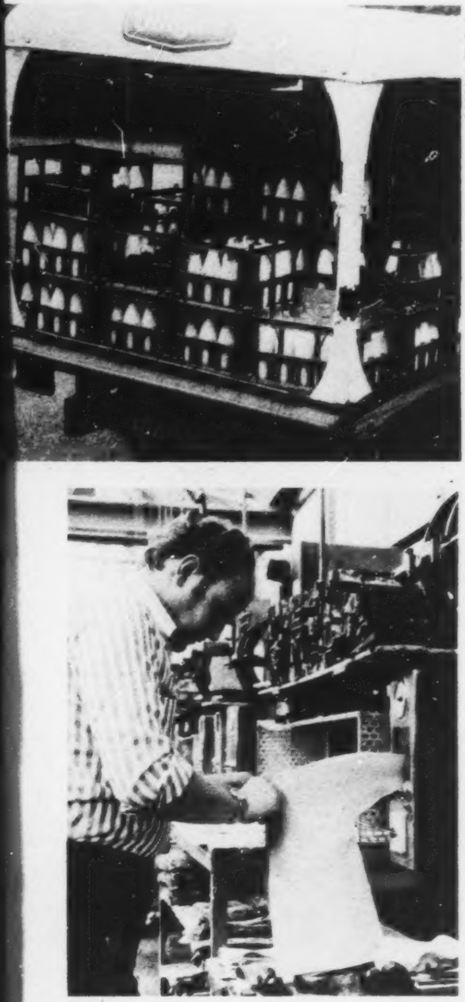
For each of HDPE, LDPE, polypropylene, and polystyrene, there are more than 20 producers. For PVC, there are more than 30. In the U.S., by comparison, 13 companies or fewer make each of the polyolefins, 17 make polystyrene, and 20 make PVC. Consequently, it would be much more difficult to arrive at some form of consensus in Europe on cutbacks and output sharing among the participants, even if such were allowable under the rules of EEC, which it isn't.

Of course, as U.S. companies have found in a crowded field such as polyester filament fiber, there is no necessary safety in numbers, but quite the opposite in a poor market. Weak producers with small or inefficient plants can be forced out rudely. In Europe, more socialistic governments damp this tendency but don't eliminate it.

Apart from sheer numbers, European ownership of thermoplastics plants is more diverse. Chemical companies, oil companies, state concerns, even banks are involved. ICI's Ray, who has compiled a profile of plant participants, figures that in the case of HDPE, chemical companies comprise 59% of the ownership, international oil companies 16%, state oil companies 15%, and other state enterprises 10%. For the five polymers as a whole, Ray's breakdown is chemical companies 53%, international oil companies 15%, state oil companies 20%, and other state industries 12%.

Yet another complicating factor is that partnerships abound. In several instances, companies have a stake in outside manufacturing enterprises making a given product as well as production facilities of their own. Also, in some partnerships only one of the partners actually markets the product. Such is the case, for example, for West Germany's Rheinische Olefinwerke. Though jointly owned by BASF and Shell, BASF has control of sales. Ray concludes, "Extra dimensions of strategy objectives are present in the industry, which contribute to the problems, and provide additional complexity to their resolution."

Despite such tangled managements, the current woeful business conditions bring up an obvious question. If companies continue to lose money on their thermoplastics operations, why don't they drop out of the business entirely? Such a solution isn't that easy for more than partnership reasons. A swing away from the polyethylenes, for example,



C&EN staff photo

Milk is delivered in HDPE crates in U.K. (above). Worker fashions PVC jackboot

would create its own set of problems for producers of ethylene, who already are contending with low plant utilization rates. Or, a cutback in ethylene production would lessen the amount of available coproduct propylene, and tend to push up its price. Since many makers of polyolefins draw on their own captive feedstock source, a shift in product portfolio would cause alternate upheavals.

Nevertheless, some company managers have bitten the bullet and have lessened their involvement in thermoplastics. U.S.-controlled managements stand out because of their relatively greater freedom to make such drastic moves. For example, Monsanto and Union Carbide sold off large chunks of their businesses to BP Chemicals four years ago. In hindsight, the decisions were adroit ones, although they elicited some consternation at the time.

Monsanto kept its 99 million lb-per-year LDPE plant at Fawley, England (ethylene is supplied over the fence from neighboring Esso Chemical), and a 55 million lb-per-year polystyrene operation at Newport, Wales. Considering the present situation, it would seem that both are prime candidates for eventual closure. Carbide, meanwhile, has a stake in European HDPE and LDPE through its joint venture with KemaNobel in Sweden's Unifos. Now going in at the Stenungsund site is a unit, one of Europe's largest, for making 330 million lb annually of linear LDPE, based on Carbide's Unipol process.

In addition to Monsanto and Union Carbide, six other U.S. companies have a position in West European thermoplastics. They are Amoco, part of Standard Oil (Ind.); Dow Chemical; Exxon's Essochem; Hercules; Occidental Petroleum, through its 50% holding in Enoxy; and Phillips Petroleum.

European producers have begun to nibble at plant closures. BASF last year permanently shut down its 88 million lb-per-year LDPE operation at Antwerp, Belgium. The product was used mainly for making fertilizer sacks. And Rheinische Olefinwerke at Wesseling, West Germany, BASF's joint venture with Deutsche Shell, has stripped 352 million lb from its 1.5 billion lb annual capacity there. These moves have cut BASF's LDPE capacity in Western Europe about one fifth. ATO and CdF Chimie in France, ICI and Shell Chemicals in the U.K., and companies elsewhere have taken actions along similar lines, or are on the verge of doing so.

BP Chemicals has a lot of unused capacity on its hands, much of it stemming from the Monsanto and Union Carbide purchases. Managing director Robert Horton now has the difficult task of trying to sort it all out and take measures to stem the financial strain on the company that its plastics involvement is proving to be. Several units have been closed. Peter Walters, British Petroleum's new chariman, has gone on record saying, "All areas and businesses of BP Chemicals are being examined. In the light of this, further plant closures can't be ruled out."

In the final weeks of last year, Montepolimeri temporarily stopped producing and selling LDPE. The decision was aimed at making "a responsible contribution to the stabilization of the market, which for many months has been characterized by a foolish waste of resources by the entire plastics manufacturing industry," commented Paolo Morrione.

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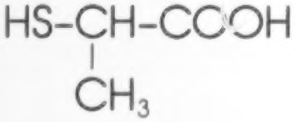

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Noting that the cost of ethylene underwent "an increase of 30% since the beginning of 1980," Morrione points out that when the decision was made, LDPE was being sold in Western Europe at 20% below the breakeven cost: "the result of the aggressive policy of some manufacturers who, by destabilizing the market, have substantially damaged the entire industrial sector."

No one argues that prices are weak, least of all the producers. A gap of about 10% on average exists between the going market price for bulk thermoplastics in Europe and manufacturers' quoted prices. BP Chemicals' Bob Horton says that a further $300 or so per ton (roughly a 20% increase) is needed on the price of thermoplastics in general. About $200 of that is required to cover higher production costs and $100 to provide some profit. He figures that companies are losing about $200 on every ton of product they sell.

Dow Europe, for one, raised its polystyrene sales price 12 to 15% at the beginning of the month. Whether this price will stick remains to be seen. The company's past attempts to improve prices and profitability weren't entirely successful.

Europeans have leveled some criticism at the U.S. over the quantities of thermoplastics shipped to Europe at what they claim have been low prices. Last year, however, shipments from the U.S. dropped noticeably.

Since then, a concern about imports has swung toward Eastern Europe, particularly with respect to LDPE and PVC. The EC Commission is acting on a complaint lodged by the European Council of Chemical Manufacturers' Federations (CEFIC) in which it claims PVC is arriving in EEC at dumped prices from Czechoslovakia, East Germany, Hungary, and Romania. CEFIC is preparing a similar case for LDPE.

According to CEFIC's data, the amount of PVC resins and compounds entering EEC from these four countries increased 47% in 1980 from 1979 to almost 262 million lb. "This increased the four countries' share of the available EEC market from 3.2 to 5%," CEFIC points out. Penetration increased further to 6.5% of 1981's market.

No less important, the price of the imports allegedly undercut EEC producers' prices up to 26%, leading to a decline in West European prices over the past two and a half years. CEFIC says that, "due to price depression caused by these dumped imports, EEC producers have failed

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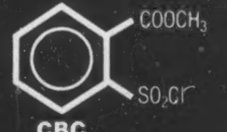

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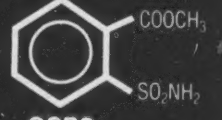

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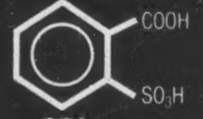

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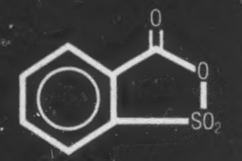

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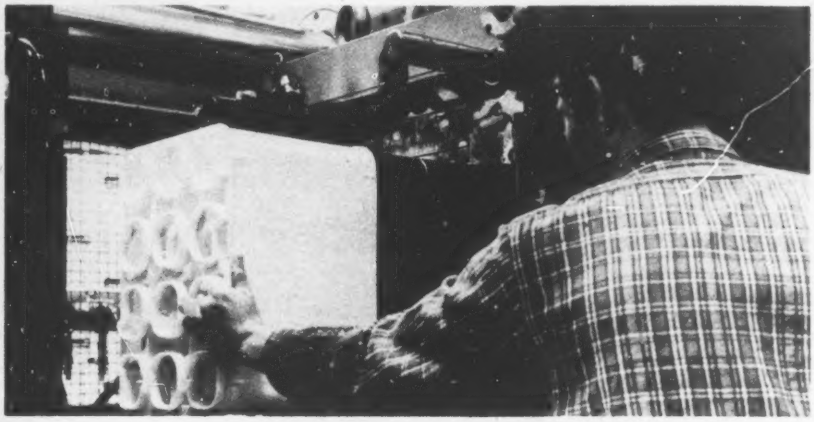
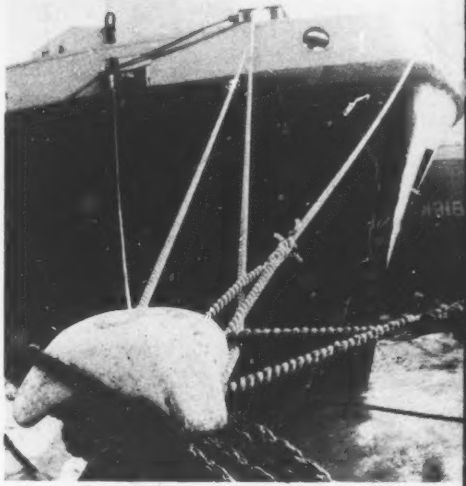




Heineken beer crates are made of HDPE (above). Ship is secured by cables fashioned from polypropylene

to cover rising costs and have encountered substantial financial losses. Moreover, several EEC producers were forced to cut production and reduce their work force."

Europeans admit to some nervousness at the prospect of competition from new producing countries. Saudi Arabia looms largest in their concern because of its geographic proximity. Within less than five years, plants now being built there will have a combined annual nameplate capacity exceeding 1.89 billion lb of polyethylene. Dow, Exxon, Mobil, and a group of Japanese companies are involved in the new plants.

The project in which Dow is participating will have an annual polyethylene capacity of 396 million lb. A likely split will be 231 million lb of HDPE and 165 million lb of linear LDPE. Exxon's capacity will be 572 million lb of linear LDPE. The Japanese consortium will have a capacity of 286 million lb of conventional LDPE. These three projects are located at Al Jubail on the Persian Gulf. At Yanbu, on Saudi Arabia's west coast, Mobil has a 50% interest in plants designed to make up to 200 million lb of HDPE and 440 million lb of LDPE yearly. The bulk of all production will be exported.

Although construction costs will be higher than the norm for such units elsewhere, Saudi Arabia is in the enviable position of having plentiful supplies of indigenous natural gas. So it is reasonable to assume that output cost per pound of the polymers will be less than for Europe.

Competition, therefore, promises to be intense, at least on a price basis. West Europeans undoubtedly will find it difficult, too, to hold onto many of their export outlets, especially those in Africa and the Middle East itself. However, executives at Saudi Basic Industries Inc. (SABIC), which owns 50% of all petrochemical projects in the country, insist that they intend to enter world markets "in an orderly manner." For producers in EEC, there is an added dimension to the Saudi problem. All Arab countries, Saudi Arabia included, are beneficiaries of EEC's Generalized System of Preferences. This means that they can sell products in EEC duty free. The preference system presupposes, of course, that the countries behave in an economically responsible way. But it raises the interesting possibility that Dow, Exxon, and Mobil will gain from the no-tariff advantage on any sales of their Saudi plastics in EEC, at least to the extent of 50% of the income, their individual percentage stakes in the ventures.

Could this be yet another cruel twist of the "outrageous fortune" European thermoplastics producers see inflicted on them, much from the outside and some of that from the U.S.? □

Naval stores markets on hold during recession

Pricing is soft as major markets suffer through recession; recovery may be quick in some areas where inventory stocks are low

Nobody in the naval stores industry is arguing that things are great—the business certainly is suffering. Actually, things could be worse, for an ironic reason: The industry's source of raw materials, the pulp and paper industry, is hurting even more. Because of that, pulpers have cut back their production, and consequently that of the by-products that constitute the raw materials for naval stores. So naval-stores producers have that much less to worry about.

Given that, naval-stores producers and marketers are saying that business is no worse than everybody else's, and that they simply have to wait out an upturn in the economy. When that comes along, however, its impact won't be felt immediately across the board for naval stores, because of a mixed inventory picture.

Turpentine producers, for example, say there is little inventory in stock among their customers, so any pickup in demand should be felt immediately. Similarly, tall-oil fatty acid stocks on hand at the end of 1981 were down nearly 26% from those on hand at the end of 1980, according to the Pulp Chemicals Association. However, year-end inventories of crude tall oil were up nearly 19% in 1981 over 1980, and those of tall-oil rosin were up 118%. And wood rosins, another major category of naval stores, were seeing inventory buildups, some sources indicate.

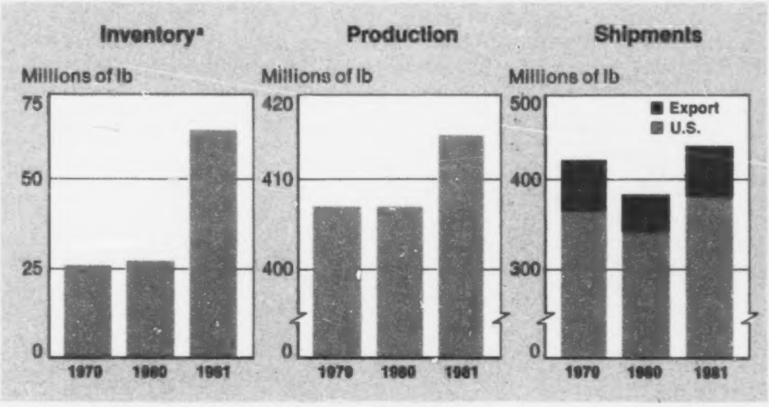
The downturn, perhaps, has been most surprising for makers of tall oil and its derivatives. Tall oil—derived from the Swedish word for pine, to distinguish the products from the pine oil that people in the U.S. associate with pine-oil disinfectants—as a feedstock has become by far the primary source of naval stores, because its production source, sulfate pulp production, has become by far the major source of pulp. Sulfate capacity now represents more than 75% of total U.S. pulp capacity, and that proportion is expected to hold if not increase over the years.

The market for tall-oil fatty acids alone in 1979 was $160 million. By 1989, that is expected to be $430 million, for consumption of some 617 million lb, according to a recent study by consultant Edward G. Hochberg, of Chester, N.J.-based Hochberg & Co. That consumption will go into a variety of areas, such as mining specialties (for example, flotation reagents), corrosion inhibitors, printing inks and coatings, rubber emulsifiers, surfactants, adhesives, and plasticizers.

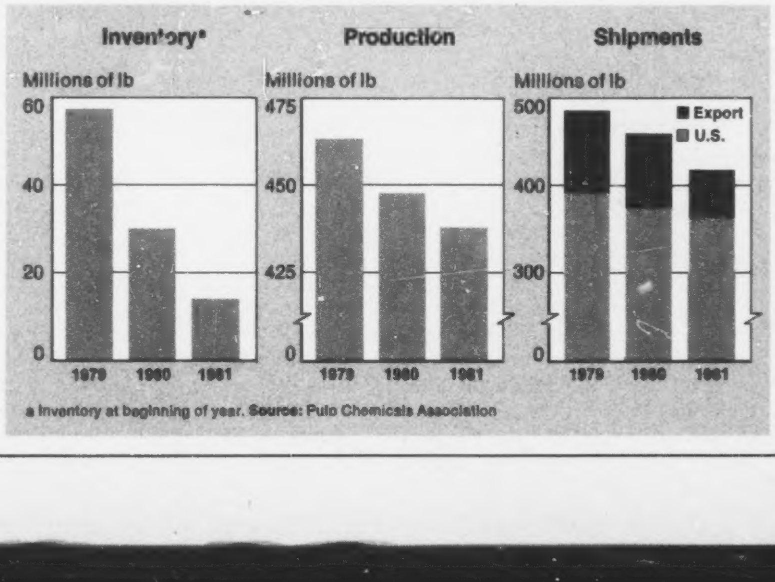
The market for tall-oil rosins—489 million lb, worth about $145 million in 1979—is expected to hit 624 million lb, with a value of $299 million, in 1989, predicts Hochberg. Most of the markets are similar to those for tall-oil fatty acids—printing inks, adhesives, rubber emulsifiers, and coatings, for example—with one other market, paper sizings.

Tall-oil rosins face general competition from wood rosins obtained by steam distillation of aged tree stumps. But a shortage of naturally aged (20 or 30 years) pine stumps has caused the technique to fall on hard times. Hercules and the other remaining producer, Reichhold Chemicals, have high hopes for a process using Paraquat that Hercules is trying out: Young pine stumps are injected with Paraquat to stimulate formation of

Tall-oil fatty acids improved after a poor 1980 . . .



. . . but tall-oil rosins continue to slow



a Inventory at beginning of year. Source: Pulp Chemicals Association rosin. If successful, the process could boost substantially wood rosin production.

If the tall-oil business really saw a slump develop only late in 1981, turpentine was in different straits. For that material, business was slow the year through. There were several reasons for the slump, but one of the major ones was a softening of one of the primary markets for turpentine derivatives, in chemicals for synthetic flavors and fragrances. Alpha-pinene, one of the two major derivatives of turpentine, is used for pine oil for disinfectants—not particularly a wildly growing product category. So fractionators have emphasized beta-pinene, which goes into higher-growth areas such as adhesives tackifiers and flavors and fragrances.

That market for beta-pinene, in turn, has shifted over the recent past, as marketers have concentrated on flavors and fragrance chemicals, with higher profit margins than tackifiers. They didn't abandon the tackifier market but they didn't wage a fierce battle against the hydrocarbon resins that came in at lower prices.

Now, however, the flavor and fragrance chemical market is softening. As one marketer points out, the U.S. and Europe account for 75 to 80% of the world's demand for flavors and fragrances. With the economies in those two regions down, some of the primary markets for synthetic flavors and fragrances, in particular—for example, air fresheners and toilet-bowl disinfectants—are discretionary purchases, and those markets have suffered somewhat. Disappointed producers put more resin back into the tackifiers business, and that hurt prices there, too.

To some extent, that can be handy, because it makes the turpentine-derived materials more competitive with petrochemical-derived products. But more important, the softening markets have backed up into turpentine to such an extent that, according to one source, some producers are burning turpentine as fuel. (Its real value to the fractionator and upgrader is less than its fuel value.) Another marketer frets over that development, terming turpentine inherently too valuable a raw material. Nonetheless, prices are off. Southeastern mill prices currently are ranging from 65 to 90 cents per gal—down from about $1.50—with differences depending upon quality and distance hauled. Canadian and far-western prices are even lower, because of lower-quality product.

Patricia Layman, New York

CHECKOFF

MERGERS

- **Air Products**—Acquires business of Empire Welding Supply Co., Denver-based cylinder gas distributor and welding equipment supplier, for undisclosed terms.

- **Armak Co.**—Subsidiary of Akzona sells pressure-sensitive tape division to Bemis Co., Minneapolis; agreement covers Armak's Marysville, Mich., plant and warehouse and business assets of operation.

  Sells fatty acid esters business, consisting of plant in Philadelphia and 50 employees, to Stepan Chemical; business sells basic ingredients to major producers and marketers of personal care and cosmetic products.

- **Ferro Corp.**—Sells its U.S. engineering activities to Eisenmann Machinery Corp. of Troy, Mich., for undisclosed terms. Transfer involves all assets, including manufacturing facilities of Temtek-Allied division of Crystal Lake, Ill., and certain other assets as well as license agreement of Ferro's U.S. and Canadian porcelain enamel engineering units. Eisenmann is affiliate of Eisenmann K.G. Maschinenbau GmbH, Boblingen, West Germany.

- **Hooker Chemical**—Sells its specialty polymers business located in Hicksville, N.Y., to Ruco Polymer Corp., a newly formed company, for undisclosed terms. Manufacture will focus on high-technology polyester polyol and urethane product lines that recently have been the unit's primary activity. Company expects 1982 sales of $30 million.

- **Linden Chemicals & Plastics**—Acquires Tridyn Industries, Greensboro, N.C., polyvinyl chloride pipe and fittings manufacturer, through Linden's LCP Plastics-North Carolina subsidiary. Acquisition includes 80,000-sq-ft facility with about 40 million lb of annual capacity.

- **NL Industries**—Sells castor oil and urethane product lines and Bayonne, N.J., manufacturing facility to CasChem, privately owned company formed to purchase the businesses. Products from facility go to telecommunications, biomedical, cosmetics, and coatings industries; anticipated sales in 1982 are about $50 million.

  Sells two 900 ton-per-day sulfuric acid plants at Sayreville, N.J., to C-I-L Chemicals of Detroit, the U.S. arm of Canadian Industries Ltd. Purchase agreement also calls for C-I-L to supply NL sulfuric acid for its titanium pigment facility in Sayreville.

- **PPG Industries**—Purchases substantially all assets, properties, and business of Hughes Chemical Co., manufacturer of adhesives and sealants based in Madison Heights, Mich., which has manufacturing and laboratory facilities in Michigan and California and had 1981 sales of about $15 million. Most of its products go to the auto industry.

- **G. D. Searle**—Sells assets of Akwell Industries to Dunlop Olympic Ltd., Melbourne, Australia, for undisclosed purchase price. Akwell, which makes latex products, becomes part of Ansell International, latex consumer and medical products division of Dunlop Olympic.

- **SmithKline**—Completes acquisition of Beckman Instruments and makes Beckman wholly owned subsidiary of new company called SmithKline Beckman. In new company, Beckman will retain its identity and continue to operate under present management. Beckman sales in 1981 fiscal year were $618 million.

- **Allied Corp.**—Sells its Converse athletic footwear division to group of investors for about $100 million in cash. Investor group is headed by Richard B. Loynd, chairman of Converse, and John P. O'Neil, president and chief executive officer. Allied got Converse when it acquired Eltra Corp. in 1979.

- **Du Pont**—Sells its domestic Vexar thermoplastic netting business to Amoco Fabrics Co. of Atlanta for undisclosed price. Vexar thermoplastic netting is based on polyethylene and polypropylene resins.

Natural gas-based petrochemicals
A Key Chemicals Review Page 18

Controversy still rages on ban
of urea-formaldehyde foam Page 34

Chemical & Engineering NEWS

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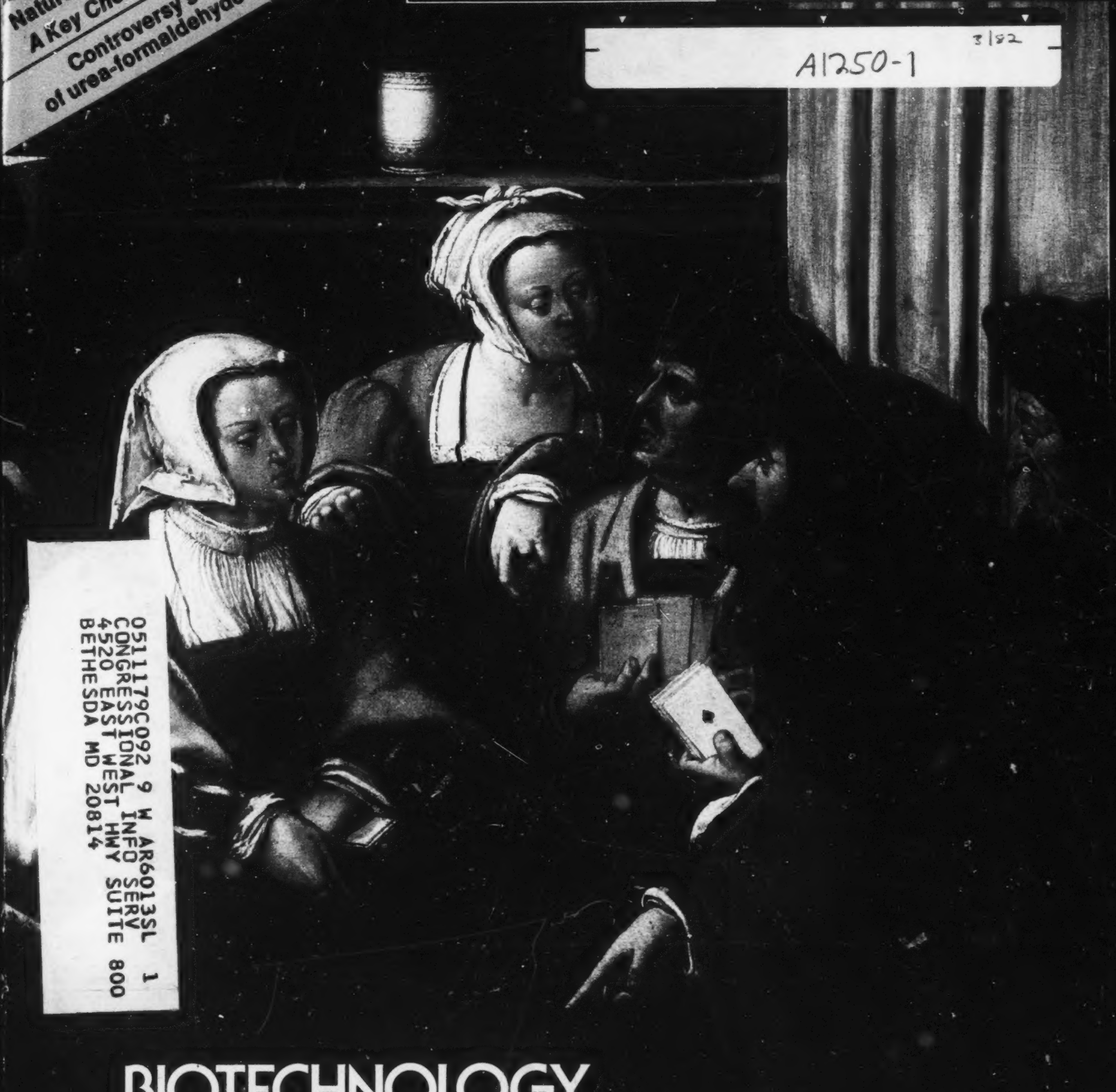

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BIOTECHNOLOGY

Stakes high, outcome uncertain
Page 10

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Chemical & Engineering NEWS

Cover: Detail from "The Card Players"; Lucas van Leyden (after). Photo courtesy of National Gallery of Art, Samuel H. Kress Collection (Washington, D.C.)

4 Letters

Concentrates
16 Business
33 Government
38 Science/Technology

The Departments
48 ACS News
60 Newscripts

News of the Week

- ***OSHA's proposed rules*** *for labeling hazardous substances in the workplace require chemical makers to evaluate their products to determine if they are health risks.* ***Page 6***
- ***GAF has had a merger offer*** *from a major corporation and bids from two other firms for its building materials business, which accounts for 55% of sales.* ***Page 7***
- ***New technology will reduce operating costs*** *of Union Carbide's Unipol linear low-density polyethylene process, increase capacity at Taft and Seadrift.* ***Page 7***
- ***American Hoechst's profits*** *in 1981 attributed to improvement in polyester fibers and pharmaceuticals sales; 1982 earnings predicted to drop.* ***Page 8***
- ***State Department accuses*** *the Soviet Union and its allies of using chemical warfare agents in Southeast Asia in report to Congress and the United Nations.* ***Page 8***

News Focus

- ***The biotechnology industry*** *is having its ups and downs financially; venture capital investors who have a stake in the business may welcome the predicted shakeout.* ***Page 10***

Business

- ***Makers of gas-based petrochemicals*** *ammonia, urea, methanol, and formaldehyde hope to at least match 1981 output even though imports cut markets.* ***Page 18***
- ***Synthesis gas-based chemicals*** *are not economical enough to attract investment without government subsidies.* ***Page 28***

Government

- ***CPSC's controversial ban*** *on use of urea-formaldehyde foam insulation affects real estate as well as industry.* ***Page 34***

Technology

- ***Conduit system*** *to transmit large amounts of electrical power underground uses sulfur hexafluoride gas as insulator.* ***Page 39***

Science

- ***Stanford struggles*** *with conflict of interest dilemma; school of medicine ad hoc committee makes recommendations.* ***Page 40***
- ***Interest stirred in electromolecular propulsion*** *as Haber Inc. looks for possible practical uses.* ***Page 40***

Science Policy

- ***Public concern arises as new force*** *in science policy; reports contend disenchantment must be reckoned with.* ***Page 43***

Books

- ***Nuclear energy*** *viewed by British science writer Ronald Clark in his latest book, "The Greatest Power on Earth."* ***Page 45***

HAZARDOUS CHEMICALS LABELING RULE PROPOSED

The Occupational Safety & Health Administration finally has issued a proposal calling for the labeling of hazardous substances present in the workplace. The announcement of the new proposal came on the eve of House hearings designed to find out why it had taken more than a year for the proposal, which was first issued and then withdrawn last January, to be reworked and reissued. Reaction from both labor and industry was swift, but divergent.

The proposed standard is very much performance-oriented and differs considerably from the approach taken by the Carter Administration (C&EN, Jan. 26, 1981, page 11). It requires chemical manufacturers to assess the hazards of chemicals that they produce, and all employers having facilities in the manufacturing sector, SIC Codes 20-39, to provide information to their employees about these hazards by means of hazard communication programs, including labels, placards, material safety data sheets, information and training, and access to written records.

The main burden of complying with the standard and most of the costs would fall on chemical manufacturers, who are defined as "establishments where chemicals are produced for use or distribution." Under the proposal, each manufacturer is required to evaluate the chemicals it produces to determine whether or not they are hazardous. Manufacturers may use whatever procedures they choose, so long as they can demonstrate that the scientifically well-established hazards of the chemicals have been ascertained adequately.

An appendix to the proposal published in the March 19 *Federal Register* contains a list of available references that employers may decide to use to do the hazard determination. However, OSHA cautions that although one source may be adequate for physical hazards, such as flammability, a more thorough search may be required to determine which chemicals present health hazards.

Once employers determine which chemicals are hazardous, they are required to label every container in the workplace with the identity of the hazardous chemical contained therein and with hazard warnings. Containers are defined as "any bag, box, can, cylinder, drum, storage tank, reaction vessel, or the like that contains a hazardous chemical. Pipes or piping systems are not considered to be containers." The warning may take whatever effective form employers wish from numerical ratings to pictographs. OSHA believes that most existing labeling systems can be used to satisfy the requirements.

Chemical manufacturers would bear most of the initial costs of the labeling standard

(SIC)	Expected initial cost ($ millions)	Cost as % of payroll	Cost as % of value-added	Average cost per employee
(20) Food and kindred products	$ 13.70	0.07%	0.03%	$ 11.90
(21) Tobacco manufacturers	0.67	0.10	0.02	13.63
(22) Textile mill products	7.43	0.10	0.05	11.07
(23) Apparel and other textile products	12.21	0.14	0.07	11.02
(24) Lumber and wood products	7.71	0.12	0.06	14.93
(25) Furniture and fixtures	4.58	0.13	0.06	12.80
(26) Paper and allied products	5.83	0.07	0.03	12.16
(27) Printing and publishing	15.04	0.12	0.05	17.37
(28) Chemicals and allied products	415.01	3.36	0.81	651.35
(29) Petroleum and coal products	1.25	0.05	0.01	12.54
(30) Rubber and plastic products	6.90	0.10	0.04	12.47
(31) Leather and leather products	2.33	0.13	0.07	12.49
(32) Stone, clay, and glass products	5.90	0.08	0.03	13.36
(33) Primary metal industries	9.51	0.06	0.03	10.59
(34) Fabricated metal products	14.76	0.08	0.04	12.62
(35) Machinery, except electrical	19.08	0.07	0.03	13.01
(36) Electrical equipment and supplies	14.91	0.07	0.04	11.10
(37) Transportation equipment	14.14	0.05	0.02	10.67
(38) Instruments and related products	4.98	0.07	0.03	12.98
(39) Miscellaneous manufacturing products	4.95	0.12	0.06	15.15

Source: Occupational Safety & Health Administration

In addition, employers must prepare material safety data sheets for each of the chemicals and make them available for worker inspection. Information on the data sheets is to include: chemical names, common names, and Chemical Abstracts Service numbers for ingredients present in specified concentrations; physical hazards and/or known chronic and acute health effects; routes of entry; precautions for safe handling and use; effective work practices and personal protective devices; emergency and first-aid procedures; and date of preparation.

The data sheet must accompany first shipments of any hazardous chemical by the manufacturers to their downstream customers, who then can rely on the data sheets to determine what hazards they must inform their own employees about. Containers leaving the manufacturers must be labeled with identity and hazard warnings, as well as the name, address, and telephone number of the manufacturer.

Other provisions of the proposed standard include: labels and warnings on mixtures comprised of at least 1% of a hazardous chemical; exemption for chemicals that are being developed and used in research labs (although chemicals being used in other labs, such as quality control labs, would be covered); and protection of trade secrets—a provision much sought by the chemical industry. Generic names can be used to mask ingredients that are trade secrets unless the chemical is a carcinogen, mutagen, or teratogen, or is a cause of significant damage to human organisms or body systems. In any case disclosure of the precise chemical substance must be made to a physician treating a patient whose health problems may be the result of occupational exposure.

Patrick Joyce of the Chemical Manufacturers Association says the present proposal is a "vast improvement" over the one offered by the Carter Administration, even though it is a "very expensive one" as far as the chemical industry is concerned. CMA still sees a few problems in the standard but feels that they are minor compared to the ones posed by the earlier proposal. CMA's general feeling is one of relief that a federal standard has been issued in light of moves by a number of states and cities to write their own labeling standards. And Joyce says the standard is evidence that this Administration will regulate in the area of health and safety, which many had contended it would not.

One of those is Sheldon Samuels of the AFL-CIO's Industrial Union Department, who sees the new proposal as further evidence that "this Administration will not respond in a morally responsible manner." He says IUD's basic objection to the proposal is that it doesn't meet the objectives spelled out in the Occupational Safety & Health Act that workers know the names of the chemicals they are exposed to. "We are not interested in management's opinion of what is and what is not hazardous," he says. "What we need are the names of the chemicals. [illegible] those, we can go to our own computers and access a wide range of sources and find out what happens when workers are exposed to different chemicals at different levels."

Samuels says that though he is sure others in the labor movement will challenge the proposal, "IUD will not waste its resources on this issue until the political climate changes to the point where a responsible standard has a chance of being promulgated." □

GAF may merge with chemical company

GAF may be the object of a takeover. Or it may sell off its important building materials business.

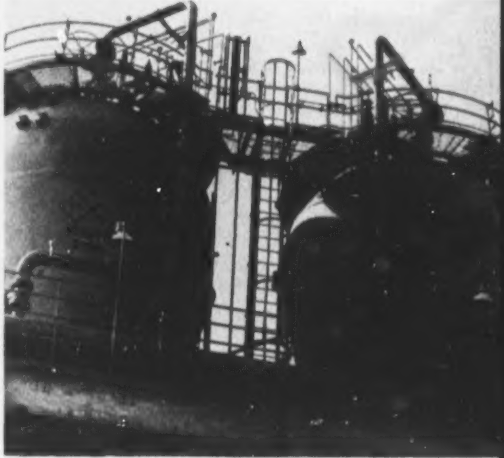
The New York City-headquartered company says that it has received inquiries from a "major corporation" asking whether GAF would be willing to be merged into that company. The major corporation has not been identified. GAF adds that it has received advances from two other companies—also unidentified—asking whether it might be willing to sell its building materials business.

The company has replied in the affirmative to all of these inquiries. So at this point it is anyone's guess what will happen.

Over the past year and a half GAF has sold off about half of its assets, leaving it essentially a building materials and chemicals company. In 1981, chemicals accounted for about 45% of GAF's sales of $673 million with building materials supplying the other 55%. More important, chemicals last year showed a pretax profit of $56.6 million, whereas building materials, battered by the recession in construction, had an operating loss of more than $38.5 million. This included a provision in the fourth quarter of $15.1 million for the possible shutdown of certain plants. Thus pretax loss from operations for building materials last year was about $23.5 million.

Although it is not known just what companies may be interested in GAF, speculation is centering on a chemical company for the merger. It would have to be a company that is not already in the roofing products business.

If the building materials business were sold off, it would leave a new medium-size chemical company with annual sales of between $300 million and $400 million. This is a far cry from GAF's size before it started its reorganization program. In 1979, the company had net sales of more than $1.2 billion. □



Twin reactors at Union Carbide's Unipol polyethylene plant in Seadrift, Tex.

Carbide lifts efficiency of linear LDPE process

Union Carbide says it has new technology that will reduce operating costs for its Unipol linear low-density polyethylene. The technology also will increase the capacity of its reactors 35% at Seadrift, Tex., and Taft, La.

The Taft unit was originally designed to produce 600 million per year of linear low-density polyethylene. The new process will boost its capacity to more than 800 million lb annually. Seadrift's capacity will be increased from 300 million lb currently to more than 400 million lb per year.

At a press conference in New York City last week, Elio E. Tarika, executive vice president of Union Carbide, stated that the technology advances also will be made available to Unipol licensees. He says the new technology is expected to give the licensees operating cost and capacity improvements in their existing Unipol plants and those under construction similar to those achieved at Taft and Seadrift.

With the new technology, Tarika says that "the investment needed to build a grass-roots Unipol process plant now can be less than one third of that customarily needed for plants using competing processes. For example, we estimate that a world-scale plant can be built today on the U.S. Gulf Coast for less than 6 cents per annual lb, despite the ravages of inflation—less than what it cost to build a state-of-the-art polyethylene plant 15 years ago."

Tarika also says that Unipol process reactors can be substituted for existing hardware in high-pressure plants for as little as 3 cents per annual lb. This, he points out, offers major advantages over converting the present reactors to production of linear low-density polyethylene.

Thus, Carbide seems to be taking aim at Dow Chemical's plan to license a process to convert high-pressure plants to linear low-density polyethylene using existing hardware (C&EN, Sept. 21, 1981, page 18).

The process also cuts energy costs for making linear low-density polyethylene, Carbide says. According to Tarika, Unipol process energy requirements, initially one fourth those of conventional high-pressure processes, have been reduced further to just one sixth the energy needed with most competing processes and as lit-

Biotechnology: a high-stakes industry in flux

Imminent shakeout in this fledgling business forecast by many observers actually might be welcomed by some groups, particularly venture capital investors

Jeffrey L. Fox
C&EN, Washington

Practically every sachem and soothsayer in the business has been quoted recently—whether in the financial sections, the Sunday supplements, or elsewhere—predicting the imminence of a shakeout in the fledgling biotechnology industry.

Several recent events—particularly a cutback and reorganization at Bethesda Research Laboratories, a biotechnology company based in Gaithersburg, Md.—are eliciting much seemingly sagacious head shaking and tut tutting. Such displays of wisdom usually are reserved for critics who expound on their favorite baseball teams when they fall into their annual August slump.

Without doubt a certain shakeout is under way in biotechnology. It began almost before the ink dried on the first set of research contracts, partnership agreements, and corporate papers. However, if the signs of a shakeout are increasingly visible, merely noticing them says very little about the makeup of this industry and what's likely to happen to it in the months ahead. Just as faded allegiance in sports fans during the late summer tells little about the glories and the difficulties of playing winning baseball, so can the current stumblings in biotechnology belie an important but complicated drama behind the scenes.

Some of that drama might have been planned by some of the participants from the start. Whether planned or haphazard, it could result in a significant rearrangement of power within the industry.

The biotechnology boom has been peculiar and by no means simple from its start. That boom is only about two years old, and thus some of the entities it has created are not likely to die yet of old age. The forces, at least some of the forces, that were instrumental in first building interest and momentum in biotechnology do not necessarily want or expect the whole thing to go immediately into seizures and collapse. Too much is happening and too much money has been invested for that result to be likely, unless the whole basis for the boom was false to start. A broad collapse isn't even considered very desirable because, even if some people might profit thereby, it's too soon for many people to profit that way.

A great deal of money is at stake in biotechnology. By low estimates at least $500 million has gone into publicly and privately held new corporations. Some financial analysts say that those investments actually could be several times higher—and that is just looking at efforts under way at the relatively new research-oriented firms and not counting how much has been invested in new programs at established chemical, pharmaceutical, and allied companies. A full-scale shakeout would mean that a major portion of that money has been squandered.

Money is squandered all the time, of course. And entrepreneurial biologists and their comrades haven't necessarily avoided making their quota of wasteful mistakes. Certainly, the rapid and proliferative growth of new companies lends itself to some unwise planning (or lack of planning), hackneyed research, and other generally wasteful business and scientific practices. It also may have lent itself to some awkward and potentially damaging misunderstandings among the various parties—the scientists, managers, investors, and anyone else involved—who have contrived to set up so many new companies having such similar overall goals.

Nonetheless, in the aggregate, this is not a group of stupid people. New to the game, certainly. But not stupid.

The participants are all playing a game, and it complicates matters that not everyone plays by the same rules. The style of play, the stakes, the varieties of short- and long-term strategies, the varied commitments of the investors and the other players—these and many other factors make an analysis of the purported biotechnology shakeout an inexact enterprise.

One factor not to be underestimated in evaluating the life expectancies of young biotechnology corporations is the private investors who have underwritten this new industry. Their patience, commitment, and wisdom must be reckoned with before more nebulous factors, such as the "mood of the market," are considered.

More than any group involved, the private investors—and particularly the venture capitalists—are the principal gamblers in the biotechnology game. If their interest at times almost seems more in savoring risks rather than in realizing monetary gains, that appearance may be deceptive. Venture capital investors can lure money away from other investors for their own use and placements for reasons that are practical as well as rakish. Venture capitalists have earned a reputation for outracing the rate of inflation. More important, they routinely outperform more timid investors. That's why more conservative money managers, such as the people who run insurance companies or who oversee pension funds, are willing to channel a small percentage of their long-term holdings into these high-risk outlets.

To deserve their reputations, venture capitalists need to stay on the winning side fairly often. Ideally, their individual investments will bring a 10-fold return or, even better, the jackpot returns that can soar another order of magnitude higher. Realistically, some investments in a particular venture capital firm's portfolio are losers. Thus, the overall return can be much more modest, possibly in the range of 20 to 30%, according to an industry source. Because that return can vary upward quite a bit, because tax advantages and a widespread gambling instinct

Documented biotechnology investments total about $500 million

Biotechnology company	Investor(s)	$ Millions
Adria Laboratories	Hercules	$1.0[a]
	Montedison	1.0[a]
Advanced Genetic Sciences	Rohm & Haas	12.0
Applied Molecular Genetics	Abbott Laboratories	5.0
	Tosco	3.5
Bethesda Research Laboratories	Private	8.0
BioCell Technology Corp.	Public offering	2.6
Biogen	Schering-Plough	8.0
	Inco	12.0
	Monsanto	20.0
	Grand Metropolitan Ltd.	10.0
Bio-Response	Public offering	5.0
Biotech Research Laboratories	Ethyl Corp.	1.0
Calgene	Allied Corp.	1.0[a]
Cetus	National Distillers	5.0
	Standard Oil of California	13.0
	Standard Oil (Ind.)	10.0
	Public offering	120.0
Collaborative Genetics	Dow Chemical	5.0
Collaborative Research	Dow Chemical	5.0
	Public offering	13.0
Collagen Corp.	Monsanto	1.0[a]
Cytox	Public offering	3.0
DNA Plant Technology Corp.	Campbell Soup Co.	10.0
DNAX Corp.	Private	1.0[a]
	Alza Corp.	1.0[a]
Engenics	Bendix, General Foods, Koppers, Mead, Noranda Mines, Elf Aquitaine	10.0
Enzo Biochem	Public offering	4.0
Genentech	Lubrizol	25.0
	Japanese group	4.5
	Fluor Corp.	9.0
	Public offering	35.0
Genetic Engineering	Public offering	4.0
Genetic Systems Corp.	Private	1.0
	Public offering	6.0
Genetics Institute	Private	5.0
Genex	Koppers	25.0
	Monsanto, Emerson Electric[b]	10.0[a]
Hybritech	Kleiner, Perkins, Caufield & Byers; Sutter Hill Ventures; Asset Management Co.	13.0
Interferon Sciences	Public offering	10.0
Molecular Genetics	Private	1.0
	American Cyanamid	5.0
Repligen	Private	5.0
Salk Institute Biotechnology Corp.	Phillips Petroleum	10.0
Southern Medical & Pharmaceutical Corp.	Public offering	23.0
	Key Energy Enterprises	7.3
Viragen	Public offering	9.0
Viratek	Public offering	4.0
TOTAL[c]		$502.9

a Industry estimate. b Via Innoven. c As of Oct. 4, 1981. Source: Sittig & Noyes

encourage participation, and because no major venture capital group so far has blown everything and failed utterly, the 50 to 100 such groups in the U.S. have received something like $1 billion annually for investing during the past few years. Only a fraction of that sum goes into biotechnology.

So what is the venture capital strategy in biotechnology?

It varies considerably, and right now may be falling into different and possibly opposite slots that could reflect the different positions and different time frames that certain venture capitalists find themselves in regarding their biotechnology placements.

Thus, for example, a venture capital group that put money into biotechnology companies several years ago and sees those companies beginning to succeed might very well begin to welcome a shakeout, expecting still newer companies—the eventual competition—to be the shakiest. However, other venture capital groups that would like to place new investments also can benefit from word of a shakeout. Fear of scarce money can force an entrepreneur to give up more equity or otherwise bargain from weakness while seeking venture capital funds.

Regardless of where a venture capital group decides to invest, it tends to evaluate each potential investment according to fairly well-accepted precepts. Though acting similarly to anyone applying principles of sound business management, venture capitalists tend to argue that they apply these rules more rigorously and possibly more shrewdly than do other investors. Moreover, venture capital placements usually come early in a company's development, thereby setting a limit on the potential loss but virtually no limit on the potential gain for the investor, should the company take off.

The managers of venture capital funds pride themselves on their ability to understand the needs and potential pitfalls of a young company. "The danger is that most young companies stumble," says Thomas Sager of Rothschild Inc., formerly New Court Securities, in New York City. Sager is part of a team administering a $46 million fund intended mainly for biotechnology. "We can bring—in addition to money—perspective and knowledge and expertise [regarding] the startup traumas faced by all young companies," he adds. "We don't know every mistake, but we've seen lots of them."

From the outset, a venture capital investor takes a long-range, or at least a medium-range, stance. "We're going in for five to seven years," Sager says. Efforts by the venture group during that period can dwarf what takes place during the initial investigation of a business plan. Others who are involved in venture capital investing say that the time frame for realizing profits from genetics research could be even longer than seven years. The point is that an astute venture capital firm knows there is a need for patience from the beginning.

"A company goes through several phases," notes Yung Wong, East Coast managing director of Menlo Ventures, a California-based partnership that so far has come close but has not closed any biotechnology deals. "We don't want to overcapitalize a company at an early stage. If we put in money, we can expect to put in more, either to help the company expand or help it through a bad time," he says.

"Most deals are in a spending mode," Sager says, referring to new biotechnology companies. Thus products and profits simply aren't expected for another few years. "We will finance people to the checkpoints we set up—not necessarily a product, maybe just a lab prototype." And thus a pattern is widely recognized whereby new ventures tend to grow in stages—sometimes in quantum leaps—depending on how well they appear to be doing. By the same logic, however, the companies usually and deliberately are kept from ever having a surfeit of cash during the early stages, lest they grow overconfident and forget how to spend that money wisely.

Deviations from this rule can and do lead companies into trouble. Bethesda Research Laboratories' (BRL) recent experiences illustrate the difficulties of adhering to this formula and what can happen when it's misused.

BRL was founded in the mid-1970s by Stephen C. Turner and a research partner. The company's first line of products included the "restriction" enzymes that are used widely for doing recombinant DNA experiments. Along with growth in biotechnology generally, BRL grew rapidly during the past few years, flourishing in part because of brisk enzyme sales. To underwrite this rapid growth, BRL received several private placements, including one from a small venture capital firm in Baltimore and, more recently, a somewhat larger private placement, according to BRL spokeswoman Michelle Hartz.

The company posted record sales revenues of more than $10 million in 1981. But, Hartz says, "We encountered cash flow problems in the past few months because of fluctuations in the business environment." Hence, according to Hartz, BRL fired about 150 employees, leaving some 300 still with the company, about 55 of them Ph.D. holders. The company also has reorganized, paring down programs in the medical diagnostics area and in genetics research. Also, the company secured $1 million in "bridge" financing and is obtaining an additional $5.5 million from private sources, mainly in Europe.

Perhaps more important, BRL's board of directors has been changed, making it "outsider dominated." Two new board members, William Janeway, director of corporate finance at F. Eberstadt & Co., the New York City investment firm that helped see BRL through its current difficulties, and Fred Adler of the New York City law firm Reavis & McGrath have been added. Adler was named chairman of the executive committee of the board, which will focus on increasing the cash flow and return on investment at BRL.

An analyst close to BRL says, "This is the finest entrepreneurial firm, bar none, in the U.S." Referring to the current mishaps, he says, "This is not unusual, just the first time in biotechnology." In saying that, he echoes what other investment analysts and venture capital strategists say about this and other new firms: They are likely to make mistakes.

However, a few oddities make the BRL case particularly noteworthy. First, the firing of scientists and other employees in a company that has been growing because of a lively sales base rattles the nerves of many observers of the biotechnology scene, particularly the people who've thrown in their lot with the industry. And second, the transfer of power, no matter how limited, from the entrepreneur director to outsiders signals a possibly significant change that might augur a general trend within the industry.

It's difficult to learn just how things got snarled at BRL. The company wanted, among other things, to go public, but public offerings aren't doing well right now. Other rumors abound regarding BRL's intentions, including one that the company was looking to be acquired. But there's little doubt that the company had been expanding at a near-reckless rate, doubling its staff and sales nearly every year. Spurred by such success, company planners broadened their horizons in leaps and bounds, and just this year BRL is introducing fairly complex instruments, including a semiautomatic nucleotide-linking machine (a "gene synthesizer"). Making and marketing such products requires plenty of capital and means competing with other experienced outfits that offer similar equipment.

The question here is not whether BRL belongs in this different, possibly lucrative, and certainly competitive marketplace. The question, rather, is who among the many experienced planners—the very people who expect young companies to need infusions of fresh cash and also expect such companies to stumble—failed to foresee what was bound to happen. An analyst familiar with BRL's current trouble says now, "Starting last summer, this operating business was transferred back into a venture mode without anyone there to control it." Turner, who is BRL's largest shareholder, "ran the company like a proprietorship," the analyst adds. "Eberstadt is partly to blame, Turner's partly to blame. It just happened."

"The reason for restructuring is to make it, solo," asserts BRL's Hartz. Turner has an "unfaltering commitment" to the company, she says. And, everyone agrees, it was Turner and the rest of BRL's management team, not the outsiders, who decided how to restructure and whom to let go.

Such decisions can exert secondary effects. In a small technology-based company, the loyalty and talents of the employees are important assets.

C&EN staff photos

Wong: firm goes through several phases

Niven: good person can save a bad idea

Weinberger: hot market at the time

Dismissing a third of them—because of mismanagement, not because of any fault of the work staff—isn't likely to raise the loyalty among those who remain. This could put Turner in an awkward predicament, especially as he seeks advice and counsel in the time ahead. He very well could be forced to look increasingly outward instead of inward to his own staff members.

BRL's experiences are not unique. For example, some restructuring recently occurred at International Plant Research Institute (IPRI), a company devoted to agricultural research and located in San Carlos, Calif. None of it was "earth shattering," according to an IPRI spokeswoman, who adds: "It's not uncommon to have changes in management all the time in a company growing so fast."

Misrock: use of R&D partnerships

"We're geared to stay independent, to build a large base of proprietary technology to make progress," IPRI president Martin A. Apple told a visitor last fall. Nonetheless, certain industry observers contend that his own independence has been curtailed somewhat. IPRI has added an acting chief executive officer, Rudolph Hurwich, to take over some of Apple's former duties. Such changes can be overemphasized and overinterpreted, of course. The point is that control at the corporate level can be fluid, especially during expansionary periods.

Regardless of these portents and despite the current recession, this still is an expansionary period for biotechnology in some ways. New deals still are being made. A generation of "fission" companies is coming to light—that is, companies that bud off from barely established entities, including IPRI and other companies, such as Genentech, which is based in South San Francisco. Several people who recently left IPRI are trying to set up their own company on the West Coast but are reluctant to discuss progress.

At least two groups have budded off from Genentech. One, called Armos, was set up "down the street" less than a year ago by former upper management people, Brian T. Sheehan and Sharon Carlock. Roberto Crea is among the founders of another company, Creative Biomolecules, also in the same area. Crea, an organic chemist who specializes in synthesizing genes, says that achieving a financial deal that he and his partners consider suitable has been difficult. However, he says, "There is no problem about money." The problem has more to do with how to structure a deal that's favorable and will allow for growth. "It's a pain in the neck to start your own organization," Crea admits, adding: "I have the luck to have a second chance, to try to build without making mistakes."

According to some venture capitalists, the recession tends to improve their position and, probably, to encourage company startups. "We're a very different subindustry," Wong of Menlo Ventures explains. "The recession hasn't affected the money coming to us. And it helps when people looking for money can't find it from traditional sources and so come to us."

Thus certain expansionary ingredients, including money, management groups, and willing scientists, are still available for new startups and for sustained activities. The biotechnology shakeout, viewed in that light, won't come about as a simple, general crash.

To be sure, new deals are being scrutinized more critically than before, or so it seems. And emphasis is shifting away from talk of research for its own sake, and more to talk of markets and other hard-nosed business realities.

Yet, for all such talk, evaluating the many biotechnology companies is not so easy, and that may be an important reason why so many separate entities have been blessed with startup money. The gossip from within some of the biotechnology companies, including ones that generally are regarded as well situated, often hints that there is a good deal of chaos, indirection, and befuddlement inside. But if there is chaos and waste, so is there much excitement and progress stemming from intense and directed research efforts.

"It's too early to divide the smart from the not so smart," says R. N. Dryden Jr., president of Agrigenetics, who runs a New York office for this Denver-based seed and agricultural research company. His conclusion sums up what a lot of people realize about the biotechnology industry. Surely it has its share of fools and charlatans, but their talents and weaknesses are not quickly or easily put to rigorous test.

A major reason is that mismatched and misdirected expectations were created at the inception of this industry. That mismatch arises from the overoptimistic use of the word "technology" in reference to virtually basic research in genetics and other similar disciplines as applied to microbes, plants, and animals. Biotechnology is a partial misnomer, depending on who uses the word and in what sense it's applied. Time is helping to cure this abuse of language (freely indulged in here for the sake of convenience). The question is whether investors and scientists can reconcile their different expectations before the scientists run out of the money that the investors have furnished.

Given the vagaries of research and the peculiar unpredictability of success in it, biotechnology is apt to need money, money, and more money before it comes into full bloom. Here again, the venture capital approach does best in setting up many entities to hedge the bets. The system works like a miniature National Science Foundation, except the aim is profit instead of discovery for its own sake.

The venture capital investor, however, does not possess the same expertise as NSF in picking research to back. "We are really investing in the people," says Wong of Menlo Ventures. He adds: "We basically invest in management, and we're betting on a guy with a proven track record. The problem with a new area is that the track record, in a sense, is not there."

"Research is crucial, but so is the ability to raise money," declares James G. Niven of Pioneer Ventures, a New York-based group that has helped to underwrite Agrigenetics. Agrigenetics has a "strong management team," he says, but admits that he is "not qualified" to judge research managers. But that is simply another aspect of the mismatch problem already mentioned: Investors who may be smart are better attuned to judging managers than scientists and other technical personnel. But as Niven points out, "A good person can save a bad idea, but a bad person can wreck a good company."

Setting aside the issue of good management—an essential problem for running any business, and one for which there are more criteria than there are businesses, investors, or people—survival of biotechnology firms becomes very much a matter of securing funds.

There are several ways to tackle this problem. Several companies—including Genentech, Bio Logicals (Toronto), Cetus (Berkeley, Calif.), and Collaborative Research (Waltham, Mass.)—have made public stock offerings. Of these companies, Cetus reaped the greatest benefits by banking about $110 million last year in its initial offering. But that experience was "an anomaly to a certain extent," says Thomas R. Weinberger of L. F. Rothschild, Unterberg, Towbin, one of the underwriters for the Cetus deal. At the time it was a "hot market" and everything more or less "came together." Since then, the value of the Cetus stock has gone down, but the firm is enjoying use of a hefty bankroll. The more recent public offering of Collaborative Research fared less well, and the initial value at which it sold its stock netted considerably less capital.

A few companies still may be fortunate to develop contract agreements with established corporate partners as a means of funding R&D efforts. But many large corporations are busy developing their own programs and have lost interest in underwriting their small competitors. Also, for small companies in which larger partners maintain possible interests, the partners are more than likely to drive harder bargains and to offer less attractive conditions than before.

Nevertheless, entirely different and sometimes highly imaginative financing schemes still are being devised. Recently Agrigenetics put together about $55 million in "limited R&D partnerships" to help fund its long-term research programs. That money, all from private placements, is more than Genentech raised in its public offering one year ago in a deal that triggered much public fantasizing and some degree of frenzy.

The Agrigenetics scheme was cooked up with the help of S. Leslie Misrock, a partner in the New York law firm of Pennie & Edmonds. Its basis is in sections of the tax code that allow individuals in high tax brackets to benefit from investing in R&D by writing off that money as expenses. And, instead of gaining a straight equity position in the entities that receive that money, the individuals, who become limited partners, are entitled to receive royalty payments after some period. Those payments are taxed as capital gains instead of ordinary income, another benefit to the limited partners—provided of course that any royalties are forthcoming. Moreover, a limited partner's intimate dealings with the R&D beneficiary also might put that partner in a favorable position to acquire equity in the company, should some opportunity arise.

Misrock envisions this and similar schemes as a way of funneling needed money into small, innovative companies. "The real innovation comes out of the hothouse atmosphere at universities and small companies, but somehow is stifled at large companies," he says. However, "most small companies are undercapitalized and haven't a clue of how to get to market with a piece of R&D. They look at research, forgetting the real cost is in development.

"I foresee the use of R&D partnerships along the lines I've sketched," Misrock continues, calling them a valuable means to support "a significant amount of research at universities and small companies." He also considers it possible that venture capital funding and "tax advantaged" R&D partnerships can be fused to carry companies through their most difficult, needy years. "I'd rather see money spent for research," he says. "If it's going to be spent, let's see it where it will do good for the nation."

Meanwhile, that channeling of money and its application to the current and near-future needs of Agrigenetics certainly will do good for the company. It ought to provide an ample cash cushion to pay for a great deal of research, both inside the company and outside—for instance, in university labs. Also, this influx of cash represents the successful cultivation of "still another segment of the investment community," Dryden of Agrigenetics points out. The individuals who make up this segment are pretty well insulated from the cold drafts of the current economy. Thus, says Dryden, "R&D partnerships can maybe get people investing even deeper into the recession."

Agrigenetics has put into action yet another ploy for success and survival, a ploy that is intended eventually to complement its long-range research emphasis. The company is aggressively acquiring seed companies—a pastime that, like basic and applied research, requires plenty of capital. "The short-term crunch for Agrigenetics will be to acquire several more companies," says Pioneer Ventures' Niven, who also sits on the board of directors for Agrigenetics. The trick in acquiring those companies is in doing so without absolute reliance on borrowing money at its current, expensively high, interest rates. For now the important goal, he argues, is to obtain a certain size. "Then, you'll make money. If you worry over money as the prime object, you can lose sight of what you're doing. Let's get there first."

Currently, "acquisitions and research are being kept at arm's length," he continues. But eventually, the two will entwine. The seed companies can put Agrigenetics into many different marketplaces. And the fruits of its research—or rather, the seeds of those fruits—then can be marketed directly.

These few examples give some idea of the transformations that are taking place, or very likely will take place, in companies dedicated to the use of genetic engineering for commercial ends. Sooner or later, these companies must reckon with the realities that their investors will impose and probably will find themselves locking into a particular course of action. Though the companies are apt to find that the available resources won't prove limitless, neither have they yet been exhausted.

People who are watching this industry during its infancy ought to be

Various services offer information about biotechnology companies

The proliferation of corporate activities on the biotechnology front makes it all but impossible for any casual observer to keep pace with the many developments. Fortunately, several guides and directories have been prepared to meet this need. These guides vary in breadth, intent, quality, and expense. A partial survey—C&EN's guide to the guides—provides some idea of what's available.

- "Applied Genetics: A Booming Industry," by Avin Brownlee and Anna W. Crull is published by Business Communications Co., P.O. Box 2070C, 9 Viaduct Rd., Stamford, Conn. 06906, and costs $1250. This report is mainly a market and technology analysis, full of charts and tables estimating possible products that will be affected by genetic engineering, noting statutes and regulations that might be affected, and providing some rundown of major patents and a computer-conducted survey of part of the relevant literature up to and including 1981. The report also includes a partial listing of companies involved in genetic engineering projects as well as a list of some of the joint projects between major established corporate entities and newer, smaller firms.
- "Biotechnology Europe," is published by Imsworld, York House, 37 Queen Sq., London, WC1N 3BL England, and costs $400. A report on biotechnology in Japan also is available for $300, as is a report on the industry in the U.S. for $500. The first report covers 14 countries in Europe and includes a section on European Economic Community activities. It includes a directory of companies.
- "The Commercial Exploitation of Biotechnical Processes in Western Europe Over the Next Twenty Years" is published by Information Research Ltd., 40/42 Oxford St., London W1N 9FJ England, and costs about $400 (195 British pounds). Besides providing a reasonably comprehensive survey of the market and product potential for biotechnology, this report offers listings of European companies and their involvements in such work. It estimates that the Western European market could grow to more than $16 billion by the year 2000, adding, however, that it's "unrealistic" to consider Europe in isolation.
- "The Genetic Engineering Industry Directory" is published by International Resource Development Inc., 30 High St., Norwalk, Conn. 06851, and costs $650. This report provides a company-by-company listing that tells where the headquarters of each company is located, who some of the major officers are, and what some of the companies' main goals, strategies, and projects are. IRD also offers several other reports and market analyses of genetic engineering enterprises.
- "Genetic Engineering & Biotechnology Firms" was prepared and published by Marshall Sittig and Robert Noyes, 84 Main St., Kingston, N.J. 08528, and costs $100. A brief survey of the scientific underpinnings of genetic technology as well as a look at potential applications is followed by a succinct listing of many of the companies (mostly those in the U.S.) engaged in such activity, which includes the location of company headquarters and some of the investment liaisons among companies. However, it does not provide names of company officers. A second, expanded version is being prepared.
- "Genetic Engineering: Business Directory" was published by Strategies Unlimited, 201 San Antonio Circle, Suite 205, Mountain View, Calif. 94040, and costs $950. This report is presented as a company-by-company listing providing a fairly detailed account of major aims of many companies in the biotechnology realm and lists members of the board of directors and board of scientific advisers when that information is available. It also gives names of major investors and the size of their investments when available.
- "An Assessment of the Global Potential of Genetic Engineering in the Agribusiness Sector" was published jointly by Policy Research Corp. and the Chicago Group, 738 North Wells St. and 744 North Wells St., respectively, Chicago, Ill. 60610, and costs $1250. This survey is directed toward agriculture but also wanders through and over some of the other subjects covered in other reports. It includes some lists of academic scientists who have done research in areas related to genetic engineering in agriculture, but is not particularly selective in this presentation.
- Several other listings and also several newsletters covering the moment-to-moment developments in this field are available at varied costs and varying credibility. They include "Genetic Engineering News," published by Mary Ann Liebert in New York City, a group that is rapidly proliferating newsletters; "Biotechnology Newswatch," published by McGraw-Hill; "Genetic Engineering Letter," published by Gershon W. Fishbein in Washington, D.C.; "Biotechnology Patent Digest," edited by Oskar R. Zaborsky in Great Falls, Va.; "BioEngineering News," published and edited by Deborah J. and Thomas G. Musiewicz in San Francisco; and "Telegen," a broad-based scan of the biotechnology literature eventually to be supplemented by a computer-assisted search service, published by Environmental Information Center in New York City.

prudent in making predictions. What may look like telltale evidence, either of imminent failure or solid success, can be misleading—out-and-out false, or at least subject to more than one interpretation. Companies like BRL may be made to play a game of brinkmanship more because they are succeeding than because they have failed in their business plan. Even slight slipups can be used in certain circumstances as an excuse for remodeling a firm's interior while leaving its facade and foundation alone.

The biotechnology companies have been hiring talented young scientists at a furious pace for the past few years. Many of these scientists have been driven from universities where they had expected to settle and lead quiet lives doing creative research. That's gotten to be increasingly difficult because, as one such scientist recently remarked, "Not only can you not eat prestige, you can't do research with it either." Thus many young scientists have allied themselves in unlikely ways with these "wildcat cloning" companies.

Research requires money and talent. Directed research requires a certain knack, and it will take time to acquire that knack and to accomplish useful things with it. The main motivating factor that investors have dangled in front of these scientists upon whom they depend is money—the chief motivator they indulge themselves with. But the sophisticated investors who've bought into the biotechnology casino know full well that another factor must be deployed with all the skills of a consummate poker player who is poised either to bluff, stand pat, or call into play whatever other strategies a particular deal may dictate.

Patience. ☐

Slump hits gas-based petrochemicals

Producers of ammonia, urea, methanol, and formaldehyde now hope to merely match last year's production and avoid losing money

Bruce F. Greek
C&EN, Houston

The leading small-molecule petrochemicals made from natural gas got away with surprisingly good business through 1980 and part of 1981 while recession hit most of the U.S. chemical industry. Now they are slumping too. And their outlook for the next five years appears to have worsened radically.

Blame recession with anemic fertilizer, housing, and fuel markets. Blame steadily rising costs of U.S. natural gas. Blame a little overinvesting by producers. And blame a rising tide of imports.

For 1982, U.S. producers of ammonia, urea, methanol, and formaldehyde now hope just to match 1981 production. Beyond that, their hopes are few. This year might be the last one in some cases for maintaining even the current production level.

Producers are holding their breath on profitability and hope they don't lose money on 1982 production when all the costs are in. Two breaks might help a bit—declines in inventory and interest costs.

However, the profitability problem will continue because of steadily rising gas costs, soft product prices, and rising imports. Ammonia and methanol in particular will be coming to the U.S. from abroad produced with much lower-cost gas.

In 1982, if production does match 1981, producers could have a gross income of $5.5 billion at most. This might be up 5% over that of 1981. But the gain is only about half of the overall real inflation rate.

Selling prices of these chemicals haven't increased much during the past year. Prospects are slim for any increase this year and later unless producers find ways to pass on the cost increases in gas. The result will be similar to what is occurring in other parts of the chemical industry—capacity declines and rising imports.

Even now, for example, considerable ammonia capacity remains shut down. This situation is a concern in the fertilizer industry in that supplies should be increasing now as the main market season begins on farms. But with ammonia imports priced as low as any produced domestically, the incentive to restart shutdown U.S. capacity is low. If the capacity was shut down some time ago when natural gas prices were lower, restarting at new, much higher gas prices is very unlikely.

Key Chemicals

Imports of ammonia could rise partly because producing countries' own plans to use their ammonia can't be met for lack of economic infrastructure. Such a condition can further reduce prices, since some foreign producers might consider a little income better than none from plants running with low-cost gas.

Methanol has a junior version of ammonia's problems. Although little, if any, methanol capacity currently is shut down, plants now operate at low levels. Prices are weak, probably no better than a year ago, further mirroring the profit squeeze. Little improvement in operating rate will occur this year.

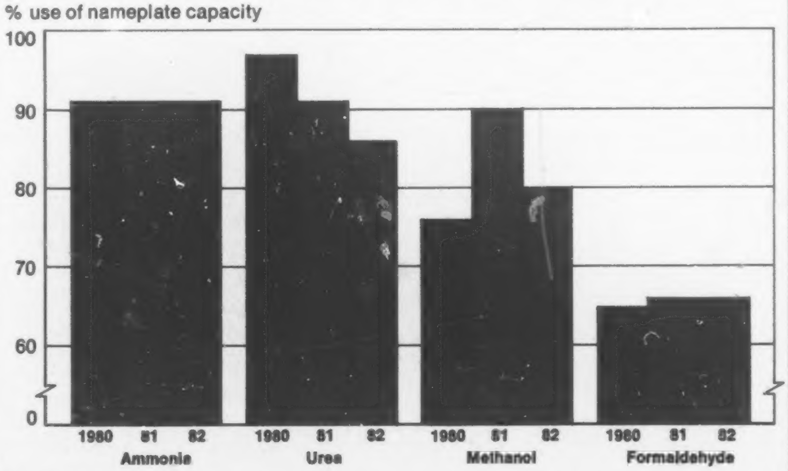
Methanol also is threatened with increasing imports from countries such as Canada, where natural gas is cheaper than gas in the U.S. The import wave might swell as decontrol of natural gas prices by whatever schedule raises U.S. gas costs.

Again, some capacity might be shut down, especially the older, less efficient plants. Retrofitting these older plants with energy-saving devices could help economics somewhat. But if the cost of imported material becomes notably lower than that produced in the U.S., even some of the more efficient plants will be shut down.

These relatively low-cost imports, now and in the future, could delay changes in natural gas-based petrochemicals' feedstocks to synthesis gas from other sources such as coal or heavy petroleum fractions in making ammonia and methanol. U.S. production from different feedstocks might not develop for a long time.

For details on the clouded immediate outlook for the major gas-based petrochemicals, see the following pages.

Some formerly high plant use rates will drop this year



Sources: Industry, C&EN estimates; Department of Commerce; International Trade Commission

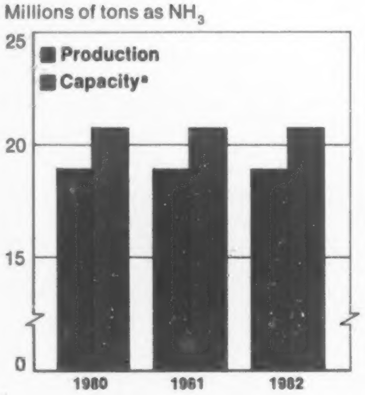
Key Chemicals

NH_3

Ammonia

- ***Demand tepid***
- ***Some capacity shut***
- ***Profits squeezed***

PRODUCTION/CAPACITY



* First quarter; includes capacity currently idled but not scrapped.

HOW MADE

Catalytic reaction of nitrogen from air and hydrogen from natural gas

MAJOR DERIVATIVES (U.S.)

Nitric acid 20%, urea 20%, ammonium phosphates 15%

MAJOR END USES (U.S.)

Fertilizer 80%, plastics and fibers 10%, explosives 5%

FOREIGN TRADE

Exports—may reach 750,000 tons in 1982, imports—to hold at about 2 million tons in 1982

PRICES

$145 to $170 per ton at Gulf Coast plants

COMMERCIAL VALUE

$3 billion for production, 1982

Ammonia, as its chemistry suggests, frequently is a maverick among petrochemicals, straying from the herd in one way or another. Using the hydrogen rather than the carbon in natural gas, the acrid compound was true to form in 1981. It avoided the demand slump in most other fertilizer-related chemicals.

But ammonia may be roped into the general recession this year. It has not started out well. Producers are beginning to get their usual seasonal upturn for the spring planting season, but hopes are not running especially high. About the only big break ammonia has going for it is a holdup on the potential import flood that always threatens this market.

Meanwhile, U.S. ammonia producers have to deal with the same background problems this year as in 1981—shutdown plants, rising costs of all-important raw material natural gas, weak farm income, and uncertain exports of derivatives. These factors alone, even without the recession, combine to keep a squeeze on profitability. Little relief lies ahead.

Companies' reaction is no surprise—a firm clamp on any new construction and shutdown or low operation of many present plants. Currently, nearly 1.5 million tons of annual ammonia capacity is shut down out of the total 20.8 million tons. Much of the rest has run during the winter at low rates between 50 and 80% of nameplate capacity.

The reason definitely has not been interruptions of natural gas supplies to ammonia plants. Despite ever-rising prices, gas limitations have been practically nonexistent. Rather, low levels of operation have been due almost entirely to slow demand combined with comfortable inventories.

Some seasonal pickup in demand is occurring as expected. Although it is too early in the spring to tell how large, production also has increased. A supply crunch during the planting season could occur if the weather opens up uniformly and farmers decide to spend more money on fertilizer instead of on other items such as equipment. These are big "if's," however, and frequently lead to surprises.

If weather and farmers' purchasing favor nitrogen fertilizer this spring, ammonia producers will have to decide quickly whether to restart currently shutdown plants. To some in the industry, none of the shutdown capacity will be needed this year. These sources assume high projections of planting intentions and a net of ammonia imports over exports. One result could be a small drawdown of inventories of ammonia and derivatives.

But other sources report that, even now, some shutdown capacity might be restarting. In a few months, perhaps an extra 1 million tons of annual capacity will be operating nearly all-out. The total production rate then would be over 20 million tons per year.

How long such a high rate holds up will depend on producers' next decision—their estimate of demand in the early part of the next fertilizer year starting in June. Producers will remember that this past fall U.S. fertilizer use disappointed them. On top of that, exports of derivatives, particularly diammonium phosphate, declined unexpectedly fast. Such events could occur this year too. Many producers doubt that very much more fertilizer will be applied this fall than a year ago. Some producers expect improved exports of derivatives this fall, but they are fresh from the shock of late 1981 and may take a wary tack.

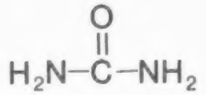
Another big question in ammonia's important foreign trade is imports. Although imports loom large from a spate of new plants around the world, all kinds of obstacles seem to have cropped up. For example, operating problems and growing internal demand might limit Mexico's ammonia exports to the U.S.

If derivatives exports increase this fall and ammonia imports don't break loose, current improved ammonia demand might hold up through the second half of 1982.

Nonfertilizer uses of ammonia are expected about the same this year as in 1981. Explosives uses are up a bit but are insignificant in total demand. Other chemical uses in downstream fibers and plastics products will do well to match 1981.

But these markets are all small compared to fertilizer. Unfortunately, they won't save ammonia producers from a lot of guesswork this year stemming from ammonia's quirky worldwide fertilizer market.

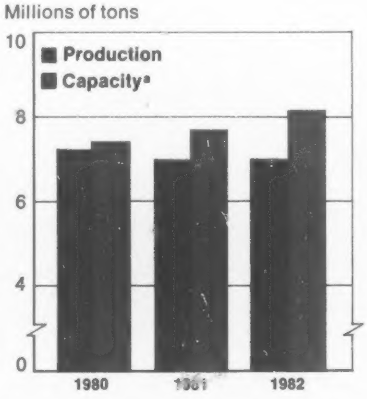
Key Chemicals


$H_2N-\overset{\overset{\displaystyle O}{\|}}{C}-NH_2$

Urea

- ***U.S. demand off***
- ***Exports way down***
- ***Good times over***

PRODUCTION/CAPACITY



[a] First quarter.

HOW MADE

Reaction of ammonia and carbon dioxide under pressure

MAJOR DERIVATIVES (U.S.)

Urea-formaldehyde resins 10%, melamine resins 5%

MAJOR END USES (U.S.)

Fertilizer 75%, adhesives and plastics 15%, animal feed 5%

FOREIGN TRADE

Exports—down sharply to as little as 1 million tons in 1982, imports—down to about 1 million tons

PRICES

$150 to $160 per ton on Gulf Coast

COMMERCIAL VALUE

$1.25 billion for production, 1982

The bloom suddenly has gone from the urea business, one of the brightest in the entire U.S. chemical industry until the fall of 1981. U.S. demand has eased, and formerly robust exports have fallen apart.

As yet, no resurgence is budding for 1982. Bad weather, of all things, might help urea this spring or early summer, but it is too early to tell.

After a long upward trend in production coupled with vigorous plant expansions, urea output tumbled in 1981—nearly 3% to 7.0 million tons, according to early estimates. Urea plants no longer ran all-out, and the scramble for raw material carbon dioxide subsided.

This winter, urea also suffered ammonia's malaise but on a smaller scale. Some capacity was shut down, and other operations ran well below optimum levels.

Some shutdown urea plants may be restarted by now, and others are scheduled to start up soon. As with ammonia, how long these plants will run and at what levels will depend heavily on weather, competition in fertilizer export markets, and inventories at various levels of distribution.

Not overweighting any of these variables, a producer consensus puts 1982 output at 7 million tons, about the same as in 1981. At this rate, nameplate plant capacity of about 8.1 million tons will run at an average of 86%. The range of estimated rates goes as low as 80% and as high as 90%.

This relatively wide range reflects the diversity of opinion on urea demand in fertilizer, its dominant outlet. The uncertainty is due largely to a surprisingly steep decline in exports in the second half of 1981 and slow export demand this winter. In 1980, exports jumped nearly a third to close to 2 million tons. Some small increase was anticipated in 1981 to push exports over 2 million tons. But to producers' dismay, exports fell because of an inventory pileup abroad in anticipation of the strong dollar and mistaken U.S. enthusiasm for worldwide demand growth. When all the figures are in, 1981 exports may total only 1.5 million to 1.6 million tons.

The wrenching shift in export demand, 300,000 to 400,000 tons, or 5% of nameplate capacity, clearly was felt in the market. Industrial uses of urea also suffered as a result of a slump in housing construction affecting urea outlets in adhesives for plywood and particle board. The total drop in 1981 demand might have been as large as 500,000 tons.

Since urea production did not fall 500,000 tons in 1981, inventories built up. A lot of that inventory overhangs the fertilizer market as urea-ammonia nitrate solutions. Carrying this inventory likely is getting burdensome, and fertilizer dealers probably are eager to move it.

But weather comes into play now. If the Midwest remains wet this spring, making field work more difficult, corn farmers might use less ammonia fertilizer in the preplanting stage. After the corn is up and strong, farmers might compensate with alternative "side dressings" of solution fertilizer to provide the required nitrogen. If this happens, the urea solution inventory would disappear and the urea business get a lift. But if the sun shines, ironically, urea might be in trouble all year unless exports somehow recover.

The nonfertilizer markets for urea are mostly in animal feed and industrial resins for various applications. The feed outlet is not expected to grow in 1982 because of competition for urea from soybeans as a nitrogen source. Soybeans might replace cotton to some extent in fields this year because of last year's bumper cotton crop and slumping cotton exports. Then soybean prices might be low and feed use might be up at the expense of urea.

The resin markets for urea are largely in making particle board and melamines. Particle board production has been falling as inventories built up with the decline in housing. Even if housing does pick up a bit in 1982, little help is due for urea because of the lag in adjusting inventories.

Melamines and the third largest resin use, plywood, have much the same outlook and a similar need for inventory pruning.

Surrounded by such markets, urea producers will need an unaccustomed patience in 1982. At least they did fairly well in 1980 and much of last year, when most of the chemical industry did not. This year they joined the crowd.

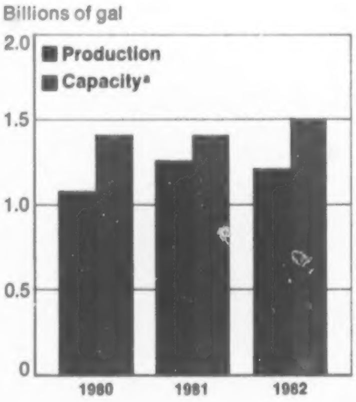
Key Chemicals

CH_3OH

Methanol

- ***Demand to ease***
- ***Capacity due way up***
- ***Prices discounted***

PRODUCTION/CAPACITY



a First quarter.

HOW MADE

Reaction of carbon monoxide with hydrogen made by reforming natural gas or heavier hydrocarbon fractions

MAJOR DERIVATIVES (U.S.)

Formaldehyde 30%, acetic acid 10%

MAJOR END USES (U.S.)

Polymers used as adhesives, fibers, and plastics 50%; solvents 10%

FOREIGN TRADE

Exports—declining to 75 million to 100 million gal in 1982, imports—holding at 30 million to 40 million gal

PRICES

List 70 to 75 cents per gal at Gulf Coast plants; discounting large

COMMERCIAL VALUE

$750 million for production, 1982

U.S. methanol producers seemed to improve much of their business last year. For instance, they increased production almost 18%, according to early estimates, and they more than doubled exports. They also improved plants to gain efficiency and some capacity.

But producers are still worried. One big concern is what they couldn't do last year—evade a profits squeeze. Costs are mounting for natural gas, the primary fuel and feedstock for methanol. Yet real methanol selling prices fell because of discounting. So far, efforts to shore up prices in 1982 haven't succeeded.

Prospects for price recovery later on aren't very good, either. The basic reason is a big investment change coming for this business. After several years of steady plant capacity and generally high capacity use, methanol faces a big block of new capacity coming on stream this year in the U.S. and Canada. Compounding the resulting dismal pricing outlook are less than expected prospects for methanol in making the new gasoline octane booster, methyl *tert*-butyl ether (MTBE), and a sickly construction market for methanol's leading derivative, formaldehyde.

In 1981, methanol enjoyed average plant use of about 90% of nameplate capacity. A big help was exports of 126 million gal for the year, two and a half times 1980 exports. Total production rose to about 1.26 billion gal from 1.07 billion gal in 1980.

In 1982, production may ease a bit. The big problem is that exports may fall 20 to 30% as new Canadian plants are started up and beat out U.S. exports on price. If the MTBE outlet does modestly well, if derivative acetic acid demand keeps growing, and if formaldehyde doesn't sink too badly, then 1982 production might be off just a bit from 1981 at about 1.2 billion gal. Plant use would stay better than average in petrochemicals at 80% of nameplate capacity.

But 1982 might be the last year for such relatively high operating rates. Late this year and early next, methanol capacity will grow more than 20% if all units under construction or modification are completed and come on stream. By mid-1983, U.S. capacity could top 1.8 billion gal a year, up from the current 1.5 billion gal. Unless 1983 turns out to be a banner year for the major uses of methanol, plant operating rates surely will decline, putting more pressure on methanol's profitability.

Other than exports, most methanol markets proved disappointing in 1981 and have done little better so far in 1982. Formaldehyde continues to face heavy downward pressure on its main end uses in resins. As a result, the share of methanol production going to formaldehyde is dropping sharply. Even the best formaldehyde growth forecasts lag well behind growth foreseen for methanol in fuels, acetic acid, and other chemicals.

Formaldehyde's difficulties stem from its dependence on housing and other construction. As a methanol outlet, formaldehyde may barely hold even in 1982 or, more realistically, decline. This decline, together with the export dip, leads industry analysts to predict the small decline in methanol production in 1982.

Among chemical uses of methanol, acetic acid continues to be a bright star. New plants have appeared making acetic acid from methanol through reaction with carbon monoxide. More are coming. This year acetic acid is forecast to take 125 million gal of methanol, most of it produced captively (in-house).

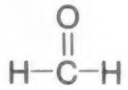
The other potentially bright star for methanol, MTBE, hasn't yet turned out to be the supernova expected by some in the industry. This year MTBE could take as much as 100 million gal of methanol, although it may not. The problem for MTBE is declining U.S. gasoline demand.

Lower gasoline demand means that there are plenty of competing gasoline blending components available, including aromatics such as toluene and mixed xylenes. Prices for these aromatics, just as useful as MTBE in octane boosting, are also competitive. So, if refiners have some unused aromatics capacity, they likely won't buy MTBE from the outside.

Other fuel uses for methanol are farther away, if possible at all, even though some developers' enthusiasm runs high. Experimental work on methanol in motor fuels will grow. However, it won't mean much to methanol producers this year. They will have to struggle to find markets for their excess capacity.

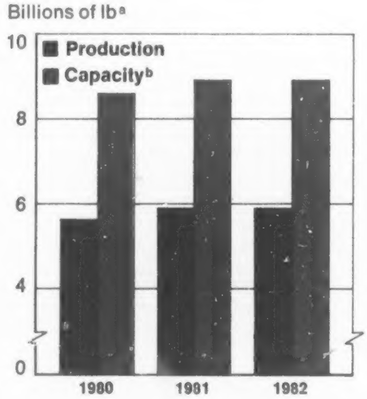
Key Chemicals

Formaldehyde


$H-\overset{\overset{O}{\|}}{C}-H$

- ***Demand weak***
- ***Plant use low***
- ***Prices discounted***

PRODUCTION/CAPACITY



a As a 37% solution. b First quarter.

HOW MADE

Catalytic oxidation of methanol

MAJOR DERIVATIVES

Urea-formaldehyde resins 30%, phenol-formaldehyde resins 20%, polyacetal resins 5%, butanediol 5%, pentaerythritol 5%

MAJOR END USES

Adhesives 60%, plastics 15%

FOREIGN TRADE

Exports—small, under 20 million lb in 1982, imports—negligible

PRICES

List about 9 cents per lb for 37% solution; discounting large; merchant volume small

COMMERCIAL VALUE

$500 million for production, 1982

Formaldehyde never had the most upbeat public image, associated as it is with funeral homes and storeroom bottles in biology class. But as a business, formaldehyde built up over the years to rank 25th among all commercial chemicals in C&EN's Top 50 listing, ranked in terms of volume produced. It found cheap mass markets, most importantly as an effective resin binder material in plywood and particle board in housing.

However, formaldehyde's public image may start to give it problems, just when the chemical can least afford it. Its business side is already in deep trouble this year because of the slump in housing. Now the product has a new setback owing to toxicity: The Consumer Product Safety Commission this quarter banned further installation of urea-formaldehyde foam insulation (see page 34).

The ban has little impact on sales of this insulation, which already have plummeted, but it adds to unfavorable opinion toward formaldehyde. That could mean lower demand sooner or later for this most important derivative of methanol.

Early estimates for 1981 formaldehyde production, at 5.9 billion lb considered too high in some quarters, would mean about 5% growth over 1980. This occurred even though most producers of urea-formaldehyde insulation quit the business. Insulation sales fell nearly to zero after early publicity on toxicity of the resin's formaldehyde.

For 1982, industry analysts believe that just matching 1981 would be a success. Even so, considerable improvement would be necessary in the economy, and the second half must bring significantly stronger demand. In other words, housing and other construction must snap back soon so that inventory of plywood and particle board starts to move into the market. Then building materials production could resurge, followed closely by an upturn in resins.

If demand for these wood products doesn't pick up smartly, then all bets are off on 1982 formaldehyde production. Continued stagnation in construction could mean as much as a 10% decline in formaldehyde production in 1982 to 5.3 billion to 5.4 billion lb (as 37% solution in water).

Operating rates for formaldehyde plants have been quite low for some time. In 1981, plant use was not over two thirds of nameplate capacity, probably a bit less. In 1982, if demand slumps, operating rates might get close to 60% of capacity.

Some capacity likely will be shut down for long periods in 1982, leading to questions on what the total operable capacity really is. A relatively large number of formaldehyde plants are small and old, with capacities less than 100 million lb a year. Often these small plants were built to supply resin material to nearby wood products plants owned either by the formaldehyde producer or by close customers.

When demand for the wood products falls, economics might weigh against continued operation of these satellite formaldehyde plants, especially if supplemental merchant sales are unavailable for the plants. Merchant sales may be difficult, since formaldehyde is seldom shipped very far.

The upshot is that some local plants now shut down may never be restarted. Economics may favor outside purchase of resins for producers of plywood and particle board.

So during 1982, expected capacity expansions of 200 million lb or so (37% solution equivalent) easily might be offset by shutdowns. The amount of capacity closed permanently could be even larger, but it will take time for the shakeout to come clear. Current total capacity is 8.9 billion lb per year.

The toxicity issue, a big potential lever for this shakeout, so far has significantly affected only a small part of formaldehyde use. Coming workplace toxicity problems, if any, haven't yet cut into formaldehyde volume to any great extent.

Smaller uses of formaldehyde generally involve a change in molecular form and so obviate downstream toxicity problems from formaldehyde per se. But these uses still are affected by changing market demand. Individually, such uses can make little difference in total demand for formaldehyde. Their growth rates, with two exceptions, are about the same as for formaldehyde itself. The exceptions with faster growth are polyacetals and acetylenic chemicals, of which butanediol is the largest.

Progress slows in chemicals from synthetic feeds

Although pushed strongly by their backers, synthesis gas-based chemicals derived from coal and other unconventional raw materials are having a hard time lately. Not only has government sponsorship lightened up, but economic analyses in private industry have become more conservative in forecasting syngas process development.

One of the most conservative new forecasts says flatly that the unconventional chemical raw materials will get little use until the turn of the century and maybe not even then, depending on cost and supply of crude oil and natural gas. Economics of synthesis gas (hydrogen and carbon monoxide) or liquid hydrocarbons made from coal, oil shale, or tar sands likely will remain unattractive for some time unless government subsidies prop up their economics.

To judge synthesis gas for wide use beyond present processes making methanol and ammonia, several economic factors must be considered, says William A. Brophy, process technologist at Chem Systems. One critical factor is the size of the synthesis gas plant. Another is the type of financing secured for a project. But probably the most important factor of all is the price of crude oil.

Current economic analyses indicate that a synthesis gas plant will need a capacity of about 200 million standard cubic feet per day to gain the necessary economies of scale. However, above this capacity level, economies don't improve much further, Brophy told a Chemical Marketing Research Association meeting in San Antonio, Tex., earlier this month.

The financing assumed by Brophy in his economic analyses includes a 70-30 debt-to-equity ratio, 20% simple return on equity, and a 20-year debt repayment schedule at a 15%-per-year interest rate. Straight line depreciation over the 20-year life is assumed. The site would be at a mine mouth in the Midwest. Coal is assumed to cost $1.85 per million Btu in 1985 and $2.78 per million Btu in 1990.

Total costs of the synthesis gas, at a 0.6-to-1 hydrogen-to-carbon monoxide ratio in 1985, would run about $3.50 per 1000 standard cubic feet. Costs would rise to about $5.50 by 1990. If this ratio were 2 to 1, costs would increase 30 cents per 1000 scf in 1985 and 55 cents in 1990. A 1-to-1 ratio would result in about half of these additional cost increments, Brophy says.

More favorable financing might lower synthesis gas costs and in fact might be necessary to provide sufficient incentive to make new chemicals based on synthesis gas. Accelerated depreciation, lower interest rates, and a lower return on equity could help but probably would not bring the effective cost below cash costs plus debt repayment, Brophy estimates.

Critical to new production economics for chemicals from synthesis gas is the price of crude oil. In general, 1990 prices of crude oil would have to be about $100 per barrel (compared to a weakening $30 at the moment) for the economics to be marginally attractive. If crude oil were $70 per bbl, Brophy says that none of the synthesis gas chemicals would be produced competitively.

For example, Brophy estimates that ethylene via naphtha or gas oil cracking in a plant with a 1 billion lb-per-year capacity would have a projected product price of 61 cents per lb in 1990 if crude oil cost $70 per bbl. (Ethylene currently lists at 25.5 cents per lb.) At the same time, ethylene made by methanol cracking would cost $1.21 per lb; by methanol homologation, 92 cents per lb; and by a modified Fischer-Tropsch process, $1.16 per lb. Credit is taken for coproduct propylene at 53 cents per lb in each route. Synthesis gas would cost $5.70 per 1000 scf for a 2-to-1 hydrogen-to-carbon monoxide ratio or $5.40 for a 1-to-1 ratio.

These costs could come down if return on equity were reduced and/or if synthesis gas costs came down to $4.00 to $4.15 per 1000 scf. They might be as low as 52 cents per lb of ethylene by naphtha or gas oil cracking, 84 cents by methanol cracking, 70 cents by methanol homologation, and 89 cents by modified Fischer-Tropsch.

These products would be a bit more competitive if crude oil cost $100 per bbl. The projected price of ethylene from naphtha or gas oil would rise to 73 cents per lb.

In other areas of unconventional feedstocks for chemicals and fuels, the outlook also is for attainment of just a tiny share of the total feedstock supply. By the year 2000, Charles R. Greene, manager of synthetic fuels at SRI International's energy center, estimates, coal liquids produced by hydrogenation might reach 125,000 bbl per day. Output might be 20,000 bbl a day by 1990.

Liquids from both oil shale and tar sands will be less than 500,000 bbl per day by 2000, well under 5% of the estimated liquid petroleum demand of 14 million bbl per day. Greene's 1990 estimate is less than 150,000 bbl per day of these liquids.

However, he emphasizes that these small production rates are still important. They would demonstrate commercial development of the technology and open a route to more energy independence for the U.S. in the event of another crude oil supply interruption. □

Potential large-scale syngas-based processes would produce both fuels and chemicals

Chemical	Process	Typical capacity	Raw material	Syngas required (millions of scf/day)
Ethylene	CH_3OH homologation	10 billion lb/year	CH_3OH-syngas	305
	CH_3OH cracking	10 billion lb/year	CH_3OH	520
	Fischer-Tropsch	10 billion lb/year	Syngas	850
Liquefied petroleum gas	Fischer-Tropsch	425 million gal/year	Syngas	975
Ethanol	CH_3OH homologation	120 million gal/[a] year	CH_3OH-syngas	22
Ethylene glycol	Union Carbide	500 million lb/year	Syngas	74
	Chevron	500 million lb/year	CH_3OH-syngas	62
Gasoline (aromatics)	Mobil	5000 bbl/day	CH_3OH	120
Acetic anhydride	Halcon/Eastman	500 million lb/year	CH_3OH/CO	49
Vinyl acetate	Halcon	350 million lb/year	$CH_3OH/CO/H_2$	60

a 70/30 ethylene/propylene. **Source:** Chem Systems

NAS president Frank Press:
Science in the 80s Page 32

First news from the Las Vegas
ACS meeting

Chemical &
Engineering **NEWS**

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National security concerns

Will they hobble science?

Page 10

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Chemical & Engineering NEWS

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2 Letters

Concentrates

18 Business
23 Government
26 Science/Technology

The Departments

43 Meetings
56 Newscripts

News of the Week

- ***Academe/industry representatives*** *discuss effects of research ties.* ***Page 4***
- ***NRC report confirms link*** *between ozone loss and skin cancer occurrence.* ***Page 5***
- ***Government's Synfuels Corp.*** *plagued by cost overruns, Congress' ire.* ***Page 5***
- ***Charles A. Thomas,*** *former ACS president and Monsanto head, dead at 82.* ***Page 6***
- ***Dow Chemical will sell*** *its oil and gas division to Apache Corp.* ***Page 6***
- ***First photos, news from Las Vegas*** *meeting, research reports on antiarthritic polymers and peptide hormone vasodilator, science adviser on academic freedom.* ***Page 7***

News Focus

- ***Will secrecy in science,*** *dictated by national security concerns, stifle free exchange of ideas and information?* ***Page 10***

Business

- ***Polyvinyl chloride market*** *is in shambles as some producers try to get out.* ***Page 20***
- ***Oxygenated octane boosters****—alcohols and ethers—growing at slower rate.* ***Page 21***

International

- ***Western European chemical industry's*** *1981 slump confirmed by statistics.* ***Page 22***

Government

- ***Chemical patents*** *continue to show the most activity in U.S., according to Patent & Trademark Office reports.* ***Page 24***
- ***Spring weather will reveal Medfly battle*** *result in California.* ***Page 25***

Science

- ***Chemistry of bridged annulene homoazulene,*** *including ground-state rearrangement, presented at Las Vegas.* ***Page 27***

AIC Medal

- ***AIC honors Milton Harris*** *with its 1982 Gold Medal at Las Vegas ceremonies.* ***Page 29***

Technology

- ***Direct methanation processes,*** *solution mining of mineral ores discussed at Las Vegas meeting.* ***Page 30***

Science Policy

- ***NAS president Frank Press*** *gives his views on a range of issues affecting science in the 1980s.* ***Page 32***

Priestley Medal Address

- ***Priestley Medalist Bryce Crawford Jr.*** *reflects on vibrational intensities.* ***Page 38***

Polyvinyl chloride shakeout gains momentum

Some producers of this key thermoplastic want to get out now as market continues to soften, but buyers are becoming hard to find

One need hardly be told that the polyvinyl chloride market is in a shambles. Production and shipments are well off from what they were last summer, prices are down, and producers are actively seeking to leave the market. The only thing that is keeping producers from getting out is that, as with the product itself, nobody seems very willing to buy a PVC plant.

Production of PVC in December hit its lowest point in almost a year and a half, according to figures compiled by the accounting firm of Ernst & Whinney for the Society of the Plastics Industry. Production in December was 321 million lb, a drop of more than 30% from December the year before. Production in December 1981 also was 42.5% below production of 559 million lb in March 1981, which had the highest production of any month last year.

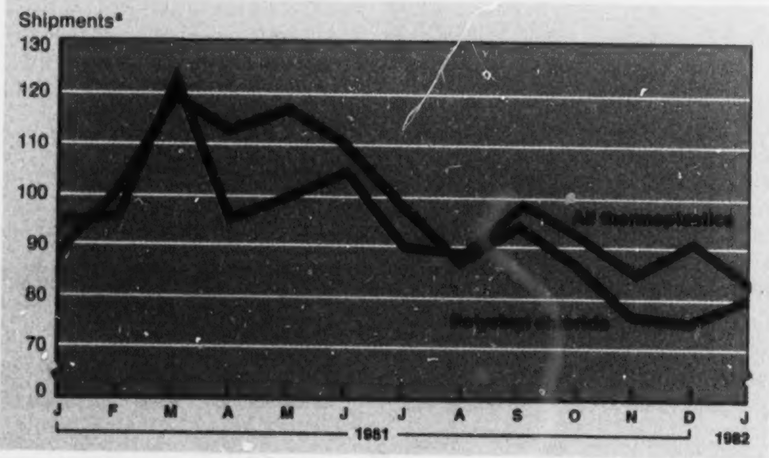
For the full year, production of PVC was up slightly from 1980. Output last year totaled 5.7 billion lb, an increase of 4.3% over 1980. Shipments of PVC, however, moved up more slowly, rising 3.9% to 5.6 billion lb from 1980.

It would be easy to blame the construction recession for PVC's problems and to a certain extent it is true that the poor housing market has pulled down PVC use over the past two years. But, in 1981, demand for PVC pipe, which is an area affected largely by construction and which accounts for about 38% of PVC resin demand, actually improved more than most other PVC end uses. Though shipments of PVC resin increased only 3.6% last year over 1980, pipe use of PVC resin rose 9% to 2.03 billion lb from 1980.

PVC production growth trailed that for all thermoplastics. Thermoplastics production increased 5.2% in 1981. Shipments of thermoplastics increased just 3.0%, making PVC outperform the broader category.

The PVC situation for January improved somewhat, although some industry observers think the improvement may be simply inventory building along the line rather than any real upswing in demand. PVC demand in January increased 11.6% to 387 million lb from December's level. Production in January moved up 11.6% to 358 million lb from December. However, shipments are still 9.6% below where they were in January 1981, and production is off 21.7%. The result was that the capacity utilization rate for all of 1981 was about 73%, but this dropped to about 50% in December.

PVC led other thermoplastics part of last year



a January 1980 shipment level = 100. **Source:** Society of the Plastics Industry

Since there is so much PVC capacity available, the price for the thermoplastic has plummeted. Although the list price is nominally above 30 cents per lb for the resin, a more realistic price is about 24 cents per lb, and there are reports that prudent shopping can secure PVC for 20 cents per lb or less.

Producers say the only thing saving them on price is the heavily discounted prices of their raw materials. Chlorine's price is steeply cut from its posted $145 to $150 f.o.b. and industry sources say that ethylene is going for as little as 17 cents per lb, down drastically from its list of a little more than 24.5 cents per lb.

With operating rates as low as 50%, it is almost axiomatic that there is production capacity that is shut down, although no one is sure just where or just how much. It is known, however, that Air Products has closed a plant, as has Pantasote, a small factor in the PVC business.

With the industry in such a shambles, it is no wonder that some producers are quite definite about getting out of the business. The latest of these was Stauffer Chemical, which sold its Delaware City, Del., plant to Formosa Plastics last year, and this year was forced to scrap its Long Beach, Calif., plant when the company could not find a buyer (C&EN, March 22, page 10). Other companies with operations on the block include Air Products, Diamond Shamrock, Pantasote, and Tenneco.

The Tenneco situation is an example of the problems involved in selling PVC operations today. It has been reported widely that the company's chemical operations are for sale, but company insiders say that the PVC business is one of the factors hindering its sale. One prospective buyer is balking at the price that Tenneco wants for its PVC operations; another company says that it will buy the chemical business, but under no circumstances does it want Tenneco's PVC plants.

William Storck, New York

Growth slows for alcohols as octane boosters

Use of alcohols and an ether as octane boosters in gasoline continues to grow. This is in spite of numerous reports of the termination of ethanol-gasoline marketing programs and cancellations of some plans to build plants to make these oxygenated compounds. But it is clear that the growth falls well short of that forecast in 1980, when gasoline apparently was in short supply.

Granted, changing economics in the petroleum refining and natural gas industries may accelerate use of these octane boosters. Other changes, however, may slow growth. Deregulation of natural gas prices or a worldwide crimp on the supply of crude oil could change use faster than economics.

Fuel uses, if they develop to the extent that some observers are forecasting, could dwarf chemical uses. For example, if gasoline consumption averages 6.25 million bbl per day and ethanol content averages 1%, about 1 billion gal per year would be needed for this use.

Currently, industry sources estimate that about 75 million gal of gasoline per month, up from about 55 million gal per month at this time last year, are being sold containing 10% ethanol. Total consumption of ethanol in gasoline in 1982 may reach 100 million gal, almost all of it made by fermentation.

Current consumption of ethanol, methanol, *tert*-butyl alcohol (TBA), and methyl *tert*-butyl ether (MTBE) as octane value improvers in gasoline still is relatively small if compared to the potential for use of these materials. Cost figures provided by advocates of these oxygenates offer incentive for their use. But some refiners emphasize that their value depends on individual circumstances and how individual refiners calculate their economics. For example, as long as toluene demand remains low for nongasoline uses such as dealkylation to benzene, refiners will tend to use toluene and other aromatics in catalytic reformates to get what they think is needed for gasoline octane values.

The scheduled October 1982 further phasedown of the use of lead alkyls as octane improvers—one of the lowest-cost additives—could increase the burden on small refiners by increasing their costs for octane value. The importance of their plight to the refining industry is comparatively small but probably critical to their continued operation.

From this analysis of the use of ethanol in gasoline—the combination now more likely to be called "superunleaded with ethanol"—Daniel C. Greer, vice president at Ashland Development, concludes that ethanol consumption will continue to rise as new fermentation plants, mostly in the Midwest, come on stream. Economics are such, he told the 80th annual meeting of the National Petroleum Refiners Association, that ethanol needs just the 4 cents per gal federal excise tax exemption to be competitive with either MTBE or toluene in terms of cost and octane improvement.

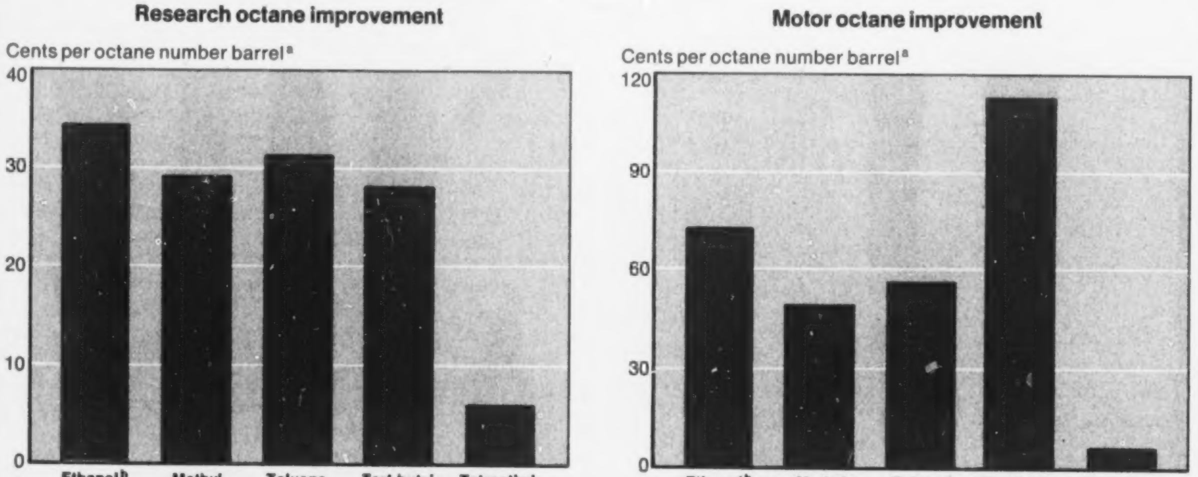
Similarly, Edward G. Guetens Jr., business manager, octane components at Arco Chemical, told the meeting that he estimates that the 9.5% volume level in lead-free gasoline of the company's blend of methanol and TBA, trademarked Oxinol, can give a 15 cent-per-gal incentive to refiners.

Recently the Environmental Protection Agency granted a waiver allowing an increase in concentration from 5.5%. The incentive, according to Arco Chemical, exists without tax credits or other incentives and despite slowing demand for gasoline.

The higher concentration of these oxygenates gives a lower blending vapor pressure for gasolines, according to Guetens. This reduces the penalty resulting from lowered use of butane in gasoline to hold down the vapor pressure.

Methanol, too, has economic advantages as an octane booster, but concerns exist over handling and materials compatibility problems, says William A. Rains, executive vice president of Roger Williams Technical & Economic Services. Because of methanol's current low cost, some will be used in gasoline illegally unless government authorities crack down on its use or until EPA regulations are changed to permit its use without a cosolvent or other additives. □

Octane enhancers vary in cost effectiveness

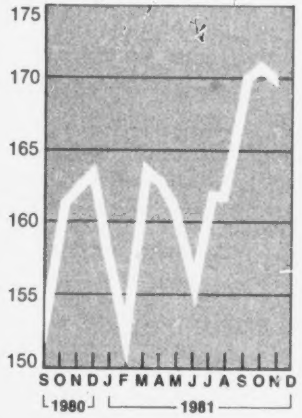


a Cost to raise octane number of a barrel of gasoline (42 gal) by 1. b Without tax exemption or vapor-pressure standard exemption. **Source:** Ashland Development Inc.

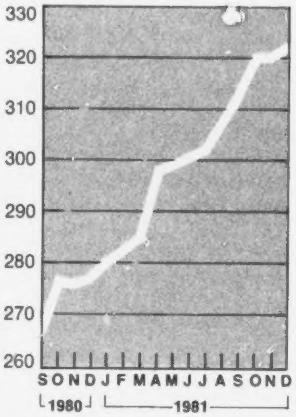
Statistics confirm Europe's slump in 1981

France

Chemical production index[a]

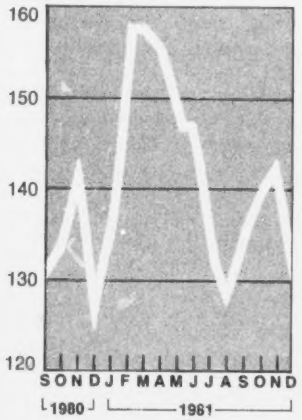


Chemical price index

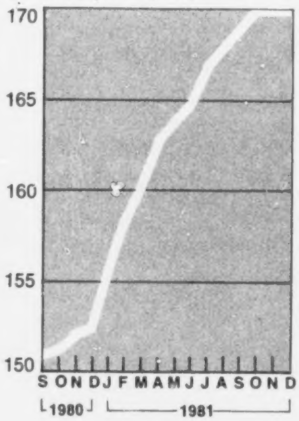


West Germany

Chemical production index

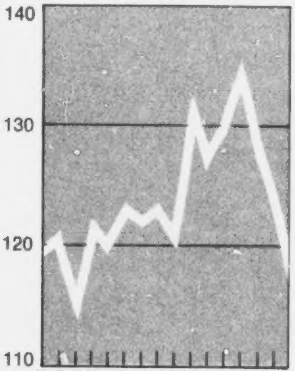


Chemical price index

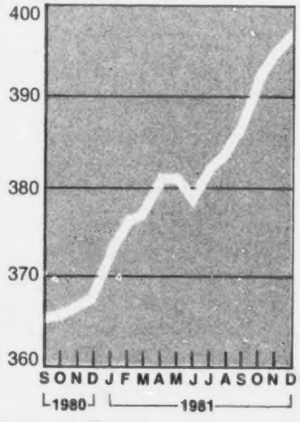


U.K.

Chemical production index[a]



Chemical price index



That the chemical industry in Western Europe fared poorly last year hardly is news anymore. But statistics now appearing lend official support to what key executives have been saying in recent weeks.

In France, the average monthly production index value for the 11 months January through November (December's figure was not available at press time) was 162.6 (1970 = 100). That is an improvement of less than 1% over the 1980 average during the like period, and 0.5% under 1979's. West Germany did slightly better with a 1.6% advance in the 1981 monthly production index average to 143.0 (1970 = 100) compared to 1980. Nevertheless, last year's average was 2.3% down from 1979's. In the U.K., the 1981 monthly average of 125.5 (1970 = 100) was almost 1% under that of 1980, and 9.3% off from 1979.

The price index profile for 1981 is more encouraging. In France, the monthly average for the full year was 302.9 (1970 = 100), up 14.2% from 1980, and not far off from the 19.0% gain in 1980 on 1979. In West Germany, the 8.6% advance to 165.1 (1970 = 100) just about matched the 8.0% improvement of 1980 over 1979. But for the U.K., there was a definite slackening in the rate of rise. Last year's monthly average increase of 6.4% to 383.6 (1970 = 100) was less than half 1980's 15.8%.

Producers' reactions to the price index rises are lukewarm. They point out that inflationary pressures on their across-the-board costs cut deeply into what gains were made. They also reason that the apparent increases mask the weaker segments of their business, such as bulk petrochemicals, where intense competition both inside and outside Europe has been keeping a lid on prices.

The same argument holds for the positive production index readings last year in France and West Germany. Ethylene output in France, for instance, fell 10% from the 1980 level to 4.09 billion lb, with crackers running at about 66% of their designed capacity levels. High-density polyethylene production was off 19% to 422 million lb, low-density polyethylene 16% to 1.52 billion lb. (Polypropylene proved the exception with output at 653 million lb, 41% ahead of 1980.)

It's not surprising that a low key is being struck on chemical investments. Last year saw a fall of some 30% in France from 1980. A further decrease of 5% is expected this year. A decrease is likely, too, in West Germany from last year's $3 billion total. Herbert Grünewald, president of the Chemical Industry Association there, predicts some 42% of this year's funding will go toward closing and replacing older units. About 36% will be spent on rationalization measures within the industry. The 22% balance will be channeled into plant expansions.

Estimates just released by the U.K. Chemical Industries Association put 1982 investment spending 7.4% ahead of last year's $2.35 billion ($1.00 = 0.5216 pound on Dec. 31, 1981) taking inflation into account. Rises foreseen for 1982, 1983, and 1984 include a hefty 23% going toward nuclear fuel treatment plants. Discounting this, and the effect of inflation, spending by the U.K. chemical industry in "real terms" is seen to rise a mere 1% this year, followed by a fall of 3% in 1983, and of 10% in 1984.

Dermot O'Sullivan, London

[a] Seasonally adjusted. **Note:** Base year for all indexes is 1970 = 100.

Most patents continue to be in chemical field

Patent office study shows that 50 major chemical subclasses accounted for 52% of patent documents added in 1978–80 period

Chemicals continue to be the largest area of patent activity in the U.S., with more patent documents filed in the various chemical categories than in both other major disciplines combined, according to the Patent & Trademark Office. PTO also finds that foreign patent activity in the U.S. is slowing down after a large increase in the early 1970s.

Of the three patent disciplines—chemical, electrical, and mechanical—chemicals are far and away the largest. PTO reports that for the three years 1978 to 1980, the 50 major chemical subclasses collected 14,340 documents, 52% of the total patents added for that period, compared to 29% of the total from electrical and just 19% from mechanical subclasses. This apparent higher growth for chemicals stems partly from the chemical industry's predilection to patent any new technology and partly from the greater scope of many of the chemical subclasses.

As in previous analyses, the 50 major chemical subclasses list is dominated by two major categories of substances. Twenty-five subclasses fall into the large area of drugs and bioaffecting and body-treating compositions, and account for 56% of the total growth in chemical patents in the three-year period. Another nine subclasses cover carbon chemistry patents, comprising 16% of the total.

But aside from sheer numbers, the growth rates of chemical patents are different. In terms of per cent growth, only one drug-related subclass is among the 50 fastest growing chemical subclasses. PTO comments that although many new patents were filed, the actual growth of the drug subclasses is small for a field so large.

Carbon compound technologies is the group that dominates the growth rate list. Of the patent documents filed in this area, 37% involve organic compounds. Of these, eight involve synthetic resins. The others range from hydrogenation of carbon oxides to ketones containing heterogeneous ring systems. PTO adds that 10% of the subclasses on this list are for patents on photoelectric panels, a finding that indicates high activity in solar technology during the 1978–80 period.

Drug categories dominate in sheer number of patents . . .

Subclass	1978–80 patents	% growth	% Foreign share	Total patents
Drugs and bioaffecting compositions with active ingredient with a five-membered ring having one nitrogen atom	639	46.5%	46.6%	3380
Drugs and bioaffecting compositions with active ingredient piperidine or derivative thereof	562	38.8	51.6	3462
Drugs and bioaffecting compositions where active ingredient has six-membered heterocyclic ring of four carbons and two nitrogens	525	38.1	55.8	3075
Analytical processes for biological systems with combinations of tests or measurements with methods of regulating a reaction	505	53.0	28.7	1593

. . . but carbon chemistry patents show largest growth rates

Miscellaneous thermolytic distillation processes	38	88.4%	68.4%	83
Synthetic resins from mixture containing solid polymer derived from aldehyde or derivative as sole reactant with no more than one methylol group	31	83.8	45.2	117
Synthetic resins from 1,2-epoxy containing reactant; a phenol, phenol ether, or inorganic phenolate; and a nitrogen-containing alcohol or ether	34	82.9	26.5	117
Hydrogenation of carbon oxides using an iron, cobalt, or nickel catalyst	60	82.2	18.3	77

Deciphering just what is happening in foreign patents originating in the U.S. is complicated. For its analysis, PTO included both patents from foreign resident inventors and U.S. patents assigned to U.S. enterprises owned or controlled by foreign companies. This way, PTO includes both technological activity of foreign countries and the foreign influence in the U.S. technology market.

Four fifths of the foreign patents held in the U.S. come from the U.K., Canada, and the Netherlands, with an increasing share coming from Japan. To simplify its analysis, PTO took the five top European and the five top Japanese companies and studied their patent activity from 1969 to 1980.

The share of U.S. patent activity by these 10 firms increased from 3% in 1969 to a peak of 5.8% in 1976, and fell to 5.5% for 1980. The total number of patents is falling also. In 1980, for example, just 3160, or 16% fewer, patents were filed by these nations than in 1979. According to PTO, this could mean lower technological activity in these companies leading to patents, or simply less interest in filing U.S. patents for their inventions.

The report notes that there is a sharp division between the kinds of technology these firms patent. The five Japanese companies hold most of the foreign patents in electrical, computer, and photography subclasses, but they are almost inactive in the areas of chemicals and drugs, where the European firms really dominate.

PTO's report, "Technology Assessment & Forecast, Tenth Report," can be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. □

NOTE

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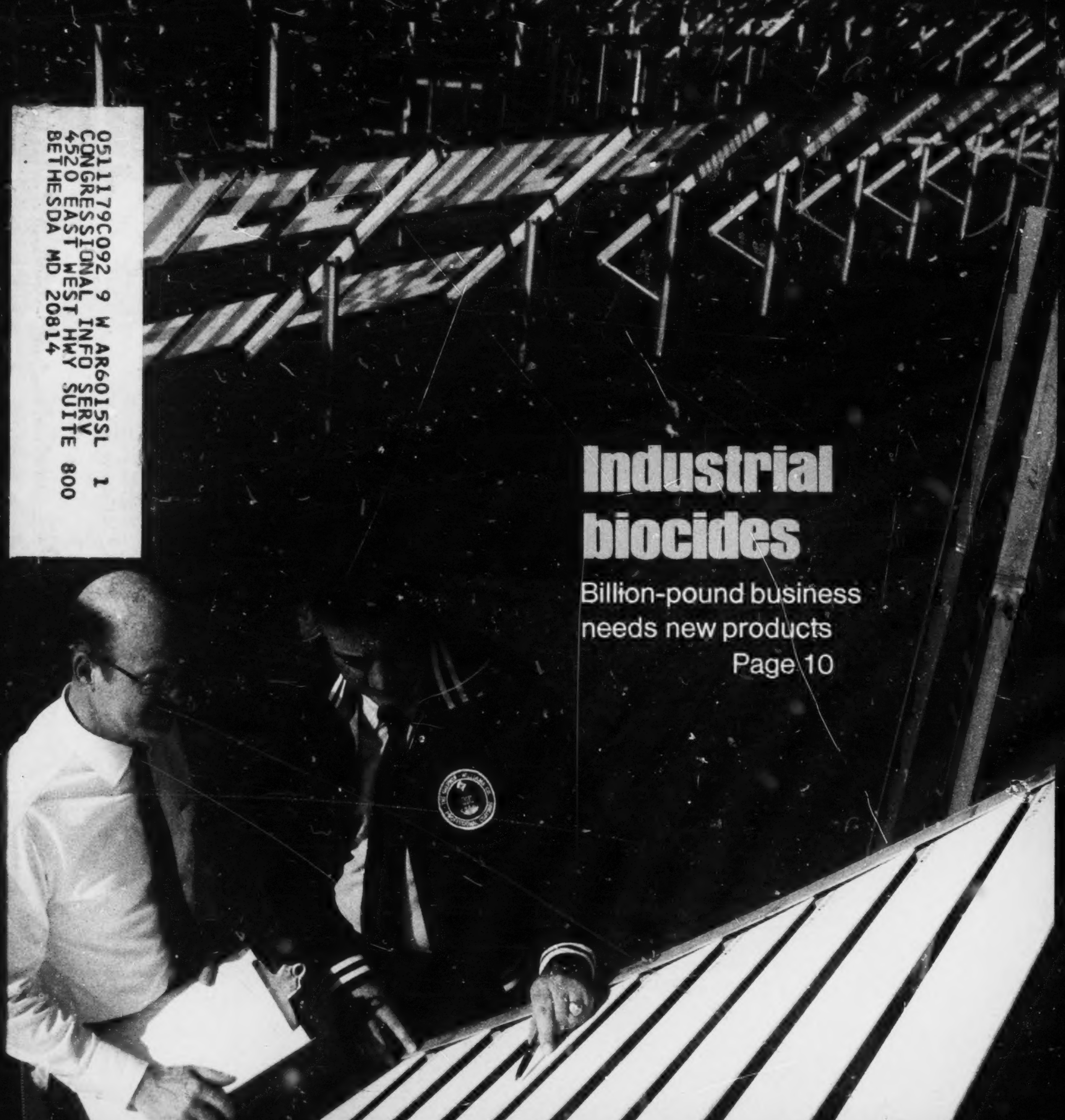

Industrial biocides

Billion-pound business
needs new products
Page 10

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Chemical & Engineering NEWS

Cover: Joint fungicide development brings together William M. Lewis of Diamond Shamrock and Steve Brotzman of Sherwin-Williams at southern Florida coatings test facility

4 Letters

Concentrates
9 Business
15 Government
23 Science/Technology

The Departments
67 Meeting Briefs
70 New Products
77 Meetings
82 People
92 Newscripts

News of the Week

- ***Chemical stocks have fallen on hard times****—they have been declining even faster than the stock market as a whole and their outlook isn't very good.* **Page 6**
- ***National minerals policy*** *released recently by the Administration aims at higher production of minerals and a beefed-up stockpile of critical materials.* **Page 7**
- ***Air cleanup "bubble policy" has been expanded*** *by EPA into more flexible program to speed up attainment of national air quality standards.* **Page 7**
- ***Foundation has been formed*** *to support research and training in the life sciences at the postdoctoral level.* **Page 7**

Business

- ***Industrial biocide makers*** *are squeezed by threat of government standards to develop new products that may not be accepted if the price is too high.* **Page 10**

International

- ***Canadian chemical industry*** *cuts production, delays or cancels construction plans to alleviate effects of recession.* **Page 14**

Government

- ***Symposium*** *reports universities seek industry R&D support, NSF commission to study high school science teaching.* **Page 16**

Science

- ***From the ACS meeting:*** *new drugs control gastric acid secretion; computer system to search chemical reactions; muonium atoms and initiation kinetics; analogy bridges organic, inorganic chemistry.* **Page 24**
- ***Molecular lanthanide*** *and yttrium hydride complexes synthesized.* **Page 32**

Education

- ***Educators should teach more scientifically,*** *include problem solving in coursework, symposium attendees conclude.* **Page 35**

ACS Annual Report

Highlights of the society's activities *in 1981 include gain in membership, plans to construct new building.* **Page 37**

Technology

- ***New waste recycling processes*** *from Europe convert plastics and tires to gas, tires to oil, paper to oil.* **Page 58**
- ***From Las Vegas:*** *two new shale oil processes set for commercialization; advances in hydrogen manufacture.* **Page 60**

ACS News

- ***Camera catches meeting-goers*** *amid the neon of Las Vegas.* **Page 74**

CHEMICAL STOCKS SLIP SHARPLY

It has not been a good season for investors in chemical stocks. Although the stock market has been declining over the past several months, stocks of chemical companies have declined even faster. And the outlook for chemical stocks may not be as good as for some other industries. In short, chemical companies are in the doghouse on Wall Street.

In the past three months, C&EN's chemical company stock index has dropped 8.4% to 185 (1954 = 100) from 202 at the end of 1981. The chemical stock index is based on stock prices of Allied Corp., American Cyanamid, Celanese, Dow Chemical, Du Pont, Monsanto, and Union Carbide. The index is weighted according to the number of outstanding shares for each company.

By contrast, broader measures of the stock market have not fared so badly in the past quarter. Probably the most widely quoted stock market indicator, the Dow Jones Industrial average, has fallen just 4.1% to 839 from a year-end index of 875.

The biggest drop through the quarter has been the American Stock Exchange index, which has fallen 17.4% to 265 since the end of 1981. However, the Amex index is dominated by oil stocks, which have fallen into even more disfavor than chemicals since the beginning of the current oil glut.

The only other major overall index to perform worse than chemicals in the past three months has been the National Association of Security Dealers Automated Quotation system (NASDAQ), the over-the-counter industrial average for small companies. This index dropped 11.4% since the end of 1981 to 203.

A year ago, the stock market was in fairly healthy shape with the Dow Jones Industrial average above 1000. And, of course, the fall in the past year is greater than in the past three months. But only the Amex index has fallen faster than chemicals in the past 12 months. In the past year, the C&EN stock index has dropped about 27% to its current 185 from 254 a year ago. The Amex index is down 28% from last year. By contrast, the Dow Jones Industrial average has fallen not quite 17% from 1007 a year ago.

Almost all of the chemical stocks making up the C&EN index were near their 12-month highs a year ago, so that the drop from the yearly high is almost the same as the drop from 12 months ago.

Allied Corp., with its heavy earnings influence from oil operations, has suffered the worst drop of the chemical companies. On Friday, April 2 (the date taken as the end of the quarter since it is the Friday immediately after the quarter ended), Allied's stock closed at $33.25, down about 37% from its stock price a year ago and down almost 45% from its yearly high of $59.875.

The stock price at Dow Chemical has fallen nearly 35% to $23.625 from its price a year ago and 39% from its yearly high.

Du Pont, which has generated a lot of criticism on Wall Street because of its takeover of Conoco, also has suffered a big stock price decline. Du Pont's stock price has fallen about 31% to $35 from a year ago and is almost 38% below its 12-month high of $56.

The best performer of the seven chemical companies making up the index was Monsanto, whose stock price has fallen not quite 12% to $64.375 from a year ago. It is, however, down 26% from its yearly high of $87.50.

The stock price for Celanese is down 17% to $55.25 from a year ago and off 20% from its high. American Cyanamid's stock price is down 20% to $27.375 from a year ago and down 25% from its $36.50 high. And Union Carbide's stock price is down 20% from a year ago to $48 and off almost 23% from its yearly high.

C&EN's chemical stock index hit its low on March 17 this year at 171 and has risen 8.2% since then to 185. However, whether this is a true turnaround in the stock, or merely a temporary increase remains to be seen. □

Chemical stock averages have performed worse than most others

	Closing average					Quarterly per cent change				Annual change
	April 2, 1982	Dec. 31, 1981	Oct. 2, 1981	July 2, 1981	April 3, 1981	April 2, 1982	Dec. 31, 1981	Oct. 2, 1981	July 2, 1981	April 3, 1981–April 2, 1982
C&EN Stock Index[a]	185.0	202.0	199.0	250.0	254.0	−8.4%	1.5%	−20.4%	−1.6%	−27.2
Dow Jones 65 stocks average	328.84	347.80	337.22	372.41	395.96	−5.5	3.1	−9.5	−6.0	−17.0
Dow Jones Industrials average	838.57	875.00	860.73	959.19	1007.11	−4.1	1.7	−10.3	−4.8	−16.7
New York Stock Exchange composite	66.22	71.11	68.80	74.73	78.14	−6.9	3.4	−7.9	−4.4	−15.3
New York Stock Exchange industrials	74.68	80.89	78.47	86.24	91.40	−7.7	3.1	−9.0	−5.6	−18.3
American Stock Exchange index	264.86	320.63	307.67	366.84	369.13	−17.4	4.2	−16.1	−0.6	−29.2
Over-the-counter composite	178.56	195.84	184.37	212.80	212.65	−8.8	6.2	−13.4	0.1	−16.0
Over-the-counter industrials	203.05	229.29	219.04	261.22	263.34	−11.4	4.7	−16.1	−2.7	−24.3
Standard & Poor's 500 stock average	115.12	122.55	119.36	128.64	135.49	−6.1	2.7	−7.2	−5.1	−15.0
Standard & Poor's 400 industrials average	127.90	137.12	133.77	144.67	153.56	−6.7	2.5	−7.5	−5.8	−16.7

[a] Weighted stock price index of Allied Corp., American Cyanamid, Celanese, Dow Chemical, Du Pont, Monsanto, and Union Carbide; weighted according to number of shares outstanding for each company. 1954 = 100.

New biocides find acceptance difficult

Low prices of traditional products stifle innovation, inhibit switch to more costly, safer biocides that meet government standards

Patricia L. Layman
C&EN, New York

Manufacturers of industrial biocides are caught between a rock and a hard place. If they develop new products that are acceptable to the government on safety grounds, they may find that the products will not make it in the marketplace because of higher prices. If they stick with the older, lower-priced products, the government is going to take a dim view of those products.

For biocides makers, current troubles date back to the early 1970s, when legislative fervor began mounting against the mercurial compounds used in a host of applications. These troubles continued and intensified into the 1980s, as other favorite products—phenolics and formaldehyde—in turn came under fire. Complicating matters, the materials haven't been banned in all cases—only thrown under a cloud of suspicion.

So manufacturers of biocides are in a quandary. Many potential customers for new products won't abandon their old standbys, particularly because these materials tend to be both effective and low in cost. Meanwhile, customers who have switched to hopefully safer materials are looking for ever-better materials to justify higher prices. But manufacturers, by and large, can't justify the massive amounts of time and money required for completely new synthesis work. So new biocidal materials are almost incidental spinoffs from pharmaceutical and agricultural chemical technology.

The major problem is the size of the biocides business—or rather, the relative lack of size. Although on a sheer poundage basis it is a more than 1 billion lb-per-year business, it is dominated by low-priced commodity wood preservatives, which pull down manufacturers' dollar value to probably about $550 million this year.

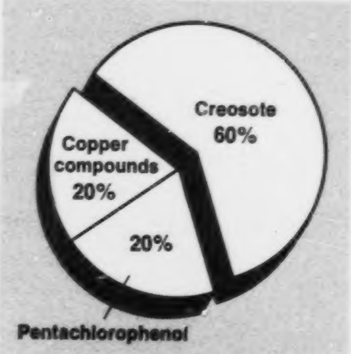
And biocides are a fragmented business. When it completed a study on biocides in 1979, C. H. Kline & Co., a Fairfield, N.J.-based consulting company, noted that there were 19 suppliers each with sales of biocides of more than $5 million, and 40 with sales of more than $1 million. Manufacturers' sales in the U.S. at the time were about $360 million, Kline estimated.

Biocides tend to concentrate on specific markets

Biocides	Disinfectants and sanitizers	Paints	Hospital products	Wood preservatives	Cooling water systems	Paper	Plastics and resins	Petroleum	Metalworking
Halogens	▨	▨	▨					▨	
Phenolics	▨			▨				▨	
Quaternaries	▨								
Organosulfurs		▨			▨	▨			
Inorganics		▨		▨					
Organometallics		▨					▨		
Nitrogen compounds								▨	▨

Source: C. H. Kline & Co.

Creosote is major biocide used in wood preservatives



1982 industrial biocides use in wood preservatives = 965 million lb

The fragmentation by company and by product application has limited the size of the commitment many companies can give to new biocides. Obtaining approval for a new biocide doesn't reach the same levels, of course, as the nearly $10 million and 10 years by one estimate that it takes to get a new agricultural chemical or pharmaceutical product approved by government agencies—but it is not tremendously less. And whereas agricultural chemicals and pharmaceuticals often offer the potential of a multimillion-dollar market, a worthwhile sales volume for a biocide is probably under $10 million per year. So it becomes difficult for a biocide maker to justify the time and expense for new materials.

That primarily explains the scarcity of new products coming to market. The latest, a brominated dicyanobutane, from Merck, was identified during a screening of pharmaceuticals and pharmaceutical intermediates (C&EN, Feb. 1, page 17). And most people in the industry expect that in the future, new biocides will come from similar work—pharmaceutical or agricultural chemical work in which some alert researcher notes properties in a compound that might be good for biocides. That suggests that companies with strong biocide interests probably also will have strength in either of the other two areas, as well, in the future.

That's true in the U.S. and it is also true in Europe, according to James R. Hickey, general manager of C. H. Kline's European operations in Brussels. Hickey, who is launching a series of studies on biocides markets in Europe, predicts a shakeout of producers of biocides, with companies with limited product lines and no cross-industry technological support facing the decision of putting substantial funds into R&D and product improvement, or getting out of the business. That probably will be true for both Europe and the U.S.

One reason why U.S. producers will face the decision is the mounting federal effort to develop registration standards for biocides. Such standards, similar to the gradient monograph program that the Food & Drug Administration is in the midst of with cosmetic and toiletry-product raw materials, will be established for classes of biocides. One of the major elements of the standards is the data supply on the materials. If there are gaps in the data, someone will have to fill them in, either through group funding of an independent research lab effort, for example, or with one producer doing the work and compensated by other manufacturers and marketers.

That will put even more pressure on some of the older biocides, in particular, which were registered many years ago when data requirements were not so stringent as they are now. If the data haven't been updated—and likely not—there will have to be some serious work done to maintain registrations. If a material is already under fire, for whatever reasons, manufacturers will have to make hard decisions about supporting or abandoning the line, perhaps trimming the number of products in a line to lessen the overall burden.

Until things become more sorted out on the regulatory front, however, the market will continue to be "new"—developed within the past 10 to 15 years—versus old.

The paint industry is perhaps one of the best examples of the marketing battle. Mercurial products long were the accepted standard for preserving both the paint formulation from bacterial spoilage and the dried paint film from mildew attack: They have broad-spectrum activity and are inexpensive. But mercurials have been banned by the Environmental Protection Agency from use in paints and coatings, except as preservatives for latex paint formulations, which have the lion's share of the trade sales, or consumer sales, paint market.

Mercurials still have a respectable business in paints, particularly with small paint makers, who see no reason to switch if they aren't forced to. By not switching, they do not have to tinker with their formulations to produce acceptable products. And they can continue to pay less than 20 cents per lb for biocides, rather than nearly 30 cents for many nonmercurials—oftentimes crucial in an industry whose profit margins can be as low as 1 to 2%.

Producers of nonmercurials have found more fertile ground with larger companies that have abandoned

Biocides work as fungicides, preservatives, sanitizers

Properly speaking, "biocide" should be the umbrella term used to describe all those products used to kill some form of living organism or tissue. But by a quirk of etymological fate, "biocide" in general has come to indicate a subsection of "pesticide," reserved for products that kill (or, as -stats, control, as in "biostats") microorganisms—bacteria, algae, slime molds, fungi, and viruses.

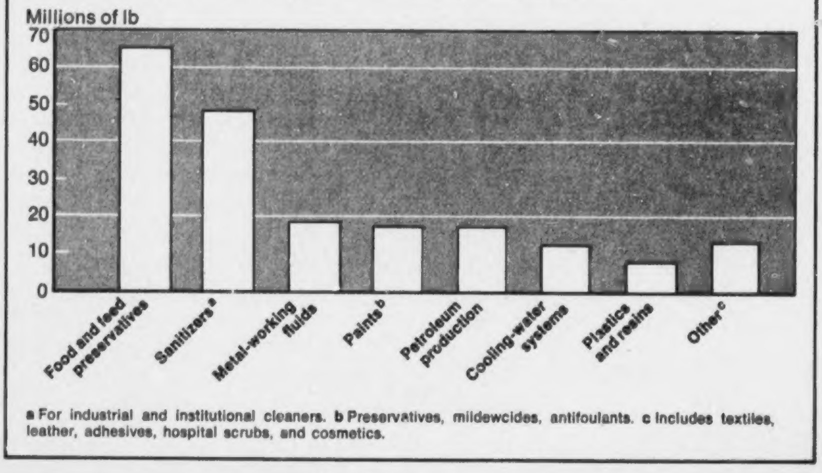
Depending on the target organism, a particular biocide might be a fungicide, most frequently a mildewcide. Or it might be a bactericide, also often called a germicide, or, in some industries, a preservative. To the cosmetics industry, for example, "preservative" sounds much more socially positive and beneficial than "biocide."

Preservation is, indeed, one of the major reasons industrial biocides are employed. In paints, they are used both to protect the wood substrate under a dried film of paint, and—in latex systems—to protect the formulation itself by preventing spoilage, foul-odor generation, loss of viscosity, and gas formation. That's biocides' function, in fact, for latex or emulsion systems in general, whether for emulsion adhesives, cosmetic and toiletry preparations, polishes, and inks; for other materials with high or even minimal contamination-level moisture content, including titanium dioxide slurries, resins, metal-working fluids, drilling muds, and fuels; and for materials to be exposed to high-humidity areas.

And, although the consumer side of the biocides industry isn't covered here, biocides are used to preserve swimming-pool systems, preventing growth of algae and slime. The halogens used for pools—iodine compounds, and chlorine-generating compounds such as hypochlorites and chloroisocyanurates—also tackle the other major job of biocides: sanitation.

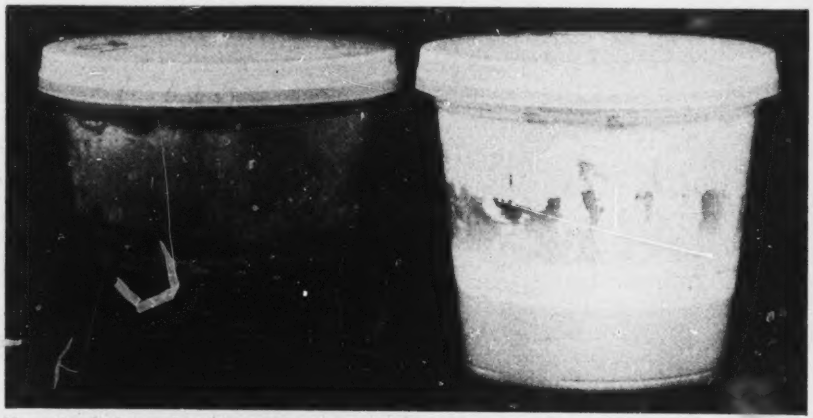
Whether as disinfectant (usually designating products applied to hard-surface areas—such as floors and walls—and to equipment, killing microorganisms but not necessarily bacterial spores), as sanitizer (implying a cleansing as well as disinfection, and a reduction or destruction of bacteria to safe public-health levels), or as sterilizer (destroying all forms of bacteria, molds, fungi, and viruses), biocides are important agents in promoting health and safety, and well-functioning and attractive products.

Many biocide markets are small and specialized



a For industrial and institutional cleaners. b Preservatives, mildewcides, antifoulants. c Includes textiles, leather, adhesives, hospital scrubs, and cosmetics.

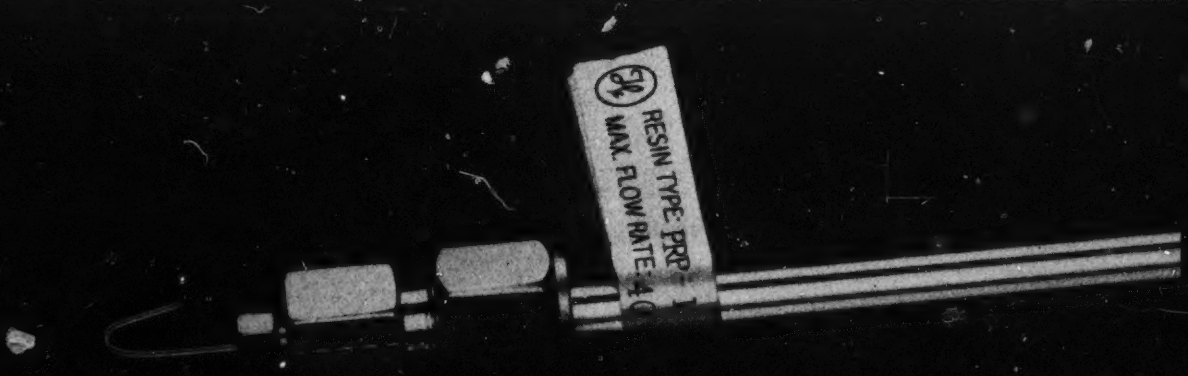
mercury as a matter of social and political policy. And they are starting to see indications that the newer products can lead to improved paint, both in terms of simpler, more rational formulations, and in terms of length of protection. The mercurials, for example, are water soluble, so eventually leach out of the exterior paint on a house, thereby ending mildew protection. Some of the newer biocides are not water soluble, so don't leach out. That means a paint maker can formulate a product with mildew protection boosted from, say, one year to four or five—a substantial marketing plus.



Unprotected rug backing compound (left) shows deterioration caused by micro-organisms; compound protected by biocide (right) retains its normal state

Similarly, longer life is one of the major selling points of the newer biocides in the marine coatings business. With marine insurers extending the periods between mandatory drydockings for engine overhaul and regular maintenance, coatings makers are being hard pressed to offer extended antifoulant performance to match. Copper oxide systems probably account for about half the business, which is essentially a global business simply because of the peripatetic nature of the substrate—a ship can be put into drydock anywhere there are facilities and the owner wishes. In fact, the U.S. marine coatings business probably is less than 15% of the total international market, with Europe accounting for 35 to 40% of the business, and the Far East the remainder—40 to 45%, heading toward 50% over the next few years.

However, organometallic technology—primarily organotin compounds—is challenging strongly for this business. Copper compounds are sensitive to harbor pollution, some sources indicate, and the leaching mechanism is unpredictable and difficult to control. It's difficult to guarantee for a full two years, which is becoming the standard time between drydockings, with six-month extensions not uncommon.



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Applications for PRP-1

HAMILTON SEPARATES

Organotin compounds lengthen the life of a copper antifoulant, so they started out as coingredients with copper. But the push lately has been to straight organotins. And recent developments with organotins chemically bound to polymers that are incorporated into paint formulations offer even more promise, as ablative, self-renewing finishes, giving a controlled "release," or exposure, of antifoulant.

Local regulations are putting some pressure on customers of biocides, perhaps even more than federal requirements. Illinois, for example, has regulations governing mercury discharge in effluent waters so stringent that it effectively knocks out mercury for paints, even for small paint makers.

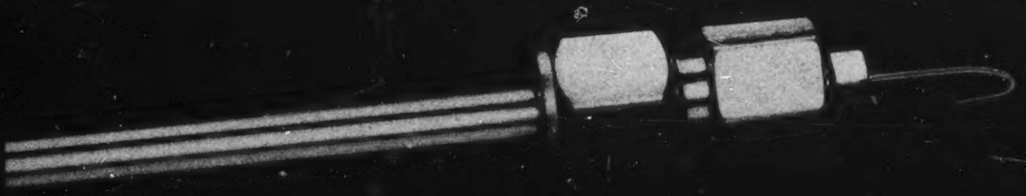
Similarly, rules such as Michigan's, which limit the concentration of phenolic compounds in wastewater effluent on the ground that they can upset treatment plants, is causing metal-working plants there to switch to other biocides, away from the phenolics. In-use performance, one marketer points out, takes a back seat to ensuring that a plant's effluent stream is not rejected by a treatment plant.

Phenolics also are under fire on biodegradability grounds, which makes quaternary ammonium compounds increasingly important for disinfectants and sanitizers, in particular. These compounds also have other advantages: They have more water solubility, so are easier to incorporate into cleanser formulations, and they don't have the distinctive odor that phenolics have.

Phenols also have been getting a drubbing in the major area of wood preservation, although environmental agitation about the compounds has not reached the level it has in Europe. Some marketers suggest that European developments may foreshadow events in the U.S., as rising costs and environmental pressures force a shift away from phenols—in particular, pentachlorophenol—and creosote-based products, to more sophisticated biocides. Organometallics are finding favor in Europe, but must be selected carefully, because basic tributyltin oxides, for example, are inactivated by soil contamination, prohibiting their use underground.

And formaldehyde, long a material of choice for many applications, is losing ground as fears of its unhealthful effect mount. Adhesives makers favored formaldehyde because it would volatilize, leaving an adhesive film with no worry about performance being affected. But a combination of bad press and occurrence of formaldehyde-resistant strains of bacteria in some plant lines is forcing a switch to other biocides. It's been a difficult job of selecting and gauging performance, adhesives chemists say, because many biocidal materials are inherently antiadhesive, and so could affect performance adversely.

If adhesives makers have had to worry about the effects of incorporating a new biocide into a formulation, biocide makers often have to worry about incorporating new base compounds into the formulations they are trying to preserve. A case in point: metal-working fluids. Traditional oils are being replaced with synthetic formulations, and producers are forced to redesign their preservative systems to handle the new products. □



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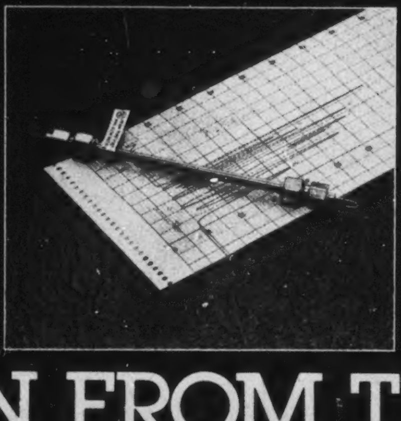
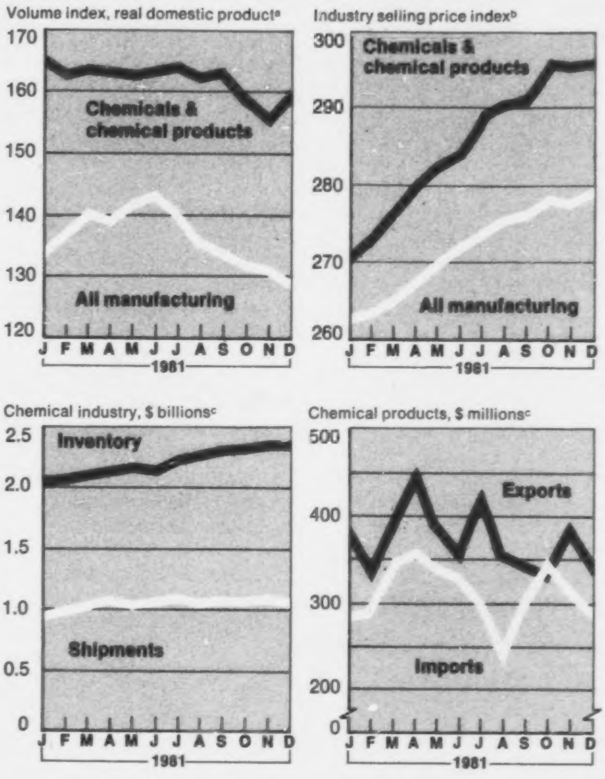


Severe recession hurts Canadian chemicals



a Seasonally adjusted; 1971 = 100. b 1971 = 100. c Canadian dollars.
Source: Statistics Canada

Only a few bright spots in chemical output

Production, thousands of metric tons	1981	1980	1979	% change 1980–81
ORGANICS				
Ethylene	1330	1197	1014	11.1%
Propylene	677	594	na	14.0
Benzene	566	560	493	1.1
Toluene	480	470	na	2.1
Xylene	410	403	na	1.7
PLASTICS				
Polyethylene, low density	451	439	428	2.7
Polyethylene, high density	223	202	200	10.4
INORGANICS				
Hydrochloric acid	186	177	154	5.1
Nitric acid	861	713	na	20.8
Phosphoric acid, 100% P_2O_5	744	808	748	−7.9
Sulfuric acid	4117	4295	3666	−4.1
Ammonia, anhydrous	2654	2556	2405	3.8
Ammonium phosphate	1355	1466	1336	−7.6
Chlorine	1292	1302	1031	−0.8
Sodium hydroxide	1458	1459	1138	−0.1

na = not available. **Source:** Statistics Canada

Like a troubled swimmer struggling toward shore, the Canadian chemical industry is striving to ride out a deep recession and make its way to the shallower waters of a better business climate.

It may be a long swim.

Most Canadian economists agree that economic recovery in Canada won't come until the third and fourth quarters of the year. Meanwhile, they are hoping that, when all of the indicators are tallied, they will show that the recession bottomed out in the first quarter. And "flat" is about the best they can do to describe the second quarter.

That means that Canadian chemical companies will be playing it close to the vest for some time to come. The signs already are apparent. Production cutbacks, delays in some construction schedules, and even outright cancellation of some building plans already are cropping up.

One big reason is the red ink that will splatter the bottom line of many chemical company annual reports. Last year started out strong for the Canadian chemical industry. But it fell apart in the second half, particularly in the fourth quarter.

Demand fell, not only in the Canadian market, but in the critically important export market. Price increases were hard to push through and Canadian chemical companies were squeezed by rapidly rising costs. The much higher costs of energy and feedstock were particularly painful.

Through this classic cost-price squeeze, producers in the organics end of the business managed to maintain a fairly healthy level of production and shipments. Ethylene output, for example, was up 11% in 1981 and production of low-density polyethylene rose 10% last year.

Inorganics, however, didn't fare so well. Output of many fertilizer materials and other heavy inorganics was down last year as high interest rates hobbled farmer purchasing in Canada and in the U.S. export market.

The impact on chemical company profits was predictable. From company to company, the story is agonizingly similar: sales up, profits down.

Sarnia-based Petrosar, for instance, pushed its sales past the billion-dollar mark for the first time, up 39% to $1.2 billion (Canadian). But net income last year fell 19%. Its neighbor Polysar increased sales 14%, yet suffered a 70% plunge in net income.

The combined sales of four other major Canadian chemical companies (C-I-L Inc., Celanese Canada, Du Pont Canada, and Union Carbide of Canada) rose 11.5% in 1981. Combined net income, however, dropped 26% (C&EN, March 1, page 14).

Feeling very uncomfortable with this profit pinch, many Canadian chemical companies are taking steps to correct it. Production is being cut back. Preliminary figures for January bear this out. Output of many fertilizer products was down in January, compared to a year ago. Even many key organics and plastics are facing production cutbacks. Ethylene output was down 3% in January, polyvinyl chloride production was off 14%, and benzene output fell a significant 31%.

Earl Anderson, New York

NOTE

ONLY THE FOLLOWING PAGES OF THIS

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Cover 1, p. 3, 63-69.

Chemical &
Engineering NE

Enoxy—corporate interview with new European chemical power
Page 18

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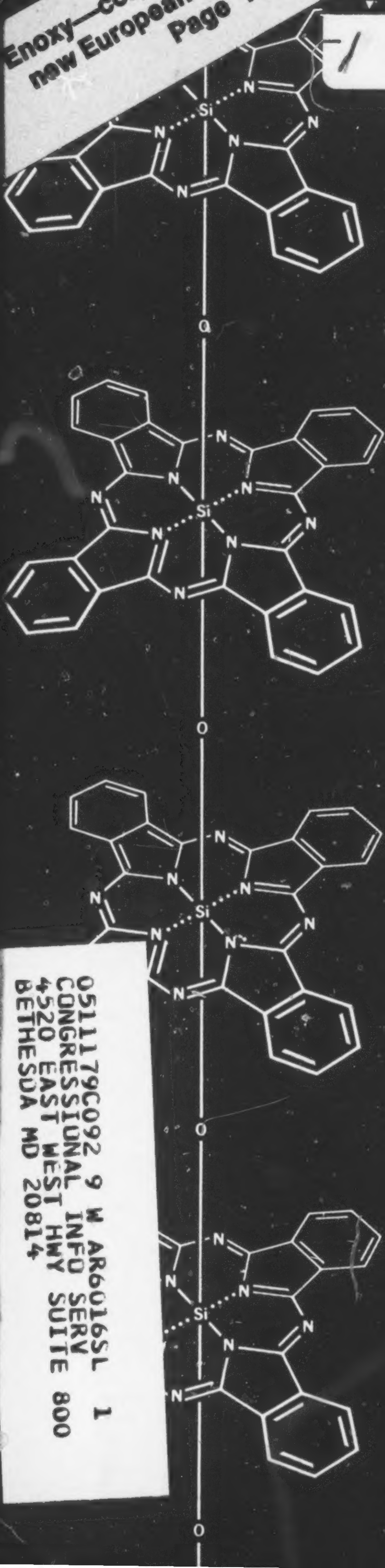
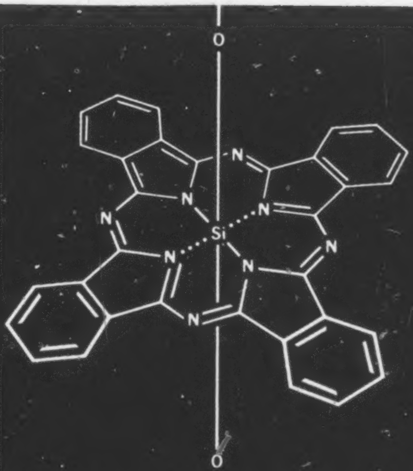
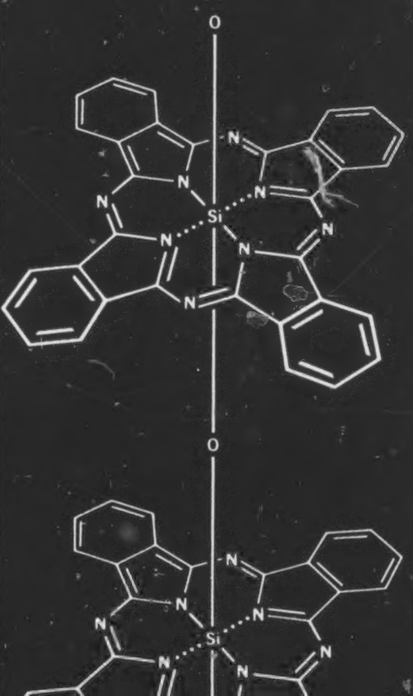




Conducting polymers

One of fast-emerging fields covered by ACS meeting symposia
Page 29



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Chemical & Engineering NEWS

4 Letters

Concentrates

13 Business
21 Government
28 Science/Technology

The Departments

70 Meetings
88 Newscripts

News of the Week

- ***Environmental Protection Agency*** *will require operators of waste disposal sites to carry liability insurance.* ***Page 6***
- ***EPA's proposed changes*** *to clean water law provoke environmental groups.* ***Page 6***
- ***Conference calls for efforts*** *to alleviate engineering faculty shortage.* ***Page 7***
- ***Reorganization*** *of National Research Council is almost complete.* ***Page 7***
- ***Use of monoclonal antibodies*** *in a diagnostic test device approved by FDA.* ***Page 8***
- ***Ronald Frankum*** *named deputy to Presidential Science Adviser.* ***Page 8***

Business

- ***Adhesives maker H. B. Fuller*** *anticipates $1 billion sales by 1987.* ***Page 15***

International

- ***Enoxy*** *acquires U.K. synthetic rubber company in first step toward becoming a multinational chemical firm.* ***Page 18***
- ***New UN system*** *for financing scientific development in developing countries described at Las Vegas symposium.* ***Page 19***

Government

- ***Toxic substances law*** *has not lived up to its potential, speakers at I&EC symposium conclude.* ***Page 23***
- ***[illegible]onomics of controlling acid rain*** *subject on session sponsored by Division of Environmental Chemistry.* ***Page 24***
- ***Changes must be made*** *in the nation's food safety laws, say participants in Chemical information Division symposium.* ***Page 25***

Science

- ***Research results*** *on topics from artificial photosynthesis to bioavailability of zinc reported at Las Vegas meeting.* ***Page 29***

Education

- ***Computer games*** *such as "Nuclear Casino" take the drudgery out of drill work for students mastering chemistry basics.* ***Page 55***

Books

- ***"Metric Madness"*** *by J. W. Batchelder attacks the switch to metric as costly and unnecessary.* ***Page 57***

ACS News

- ***Council approves $4.00 dues increase*** *and acts on petitions at a four-hour session in Las Vegas.* ***Page 60***
- ***University of North Carolina, Chapel Hill, regains its status*** *as top producer of B.S. and Ph.D. chemistry graduates.* ***Page 63***
- ***ACS Committee on Professional Training 1981 annual report*** *shows B.S. chemistry graduates increased almost 3%.* ***Page 64***

Chapel Hill again tops new graduate list

The University of North Carolina, Chapel Hill, and the University of Illinois, Urbana-Champaign, have regained their status as the nation's largest producers of B.S. and Ph.D. chemistry graduates, respectively, according to data gleaned by C&EN from the latest annual report of ACS's Committee on Professional Training (CPT).

This committee is the mechanism by which ACS both sets standards for undergraduate education in chemistry and monitors such programs at more than 500 schools. The committee does not set standards or monitor graduate chemistry programs, but it does gather data on them. It also gathers data on chemical engineering programs. (The full text of the committee's latest report covering the 1980–81 academic year starts on page 64).

In 1979–80 Indiana University dislodged Chapel Hill from a six-year reign as the largest producer of B.S. chemists. But in the 1980–81 report, Chapel Hill surges back to the top with a total of 156 such graduates, and Indiana slips to second with 132. The University of California, Los Angeles, moves up from seventh to take third place with a total of 126 B.S. graduates.

Similarly, a six-year reign by Urbana-Champaign as the largest producer of Ph.D. chemists was interrupted in 1979–80 by the University of California, Berkeley. In the latest report Urbana-Champaign is firmly back on top with 73 new Ph.D. chemists; Berkeley slips to second with 45. Purdue takes third place with 39 Ph.D. graduates.

For the seventh consecutive year the University of California, San Diego, is the largest producer of certified B.S. chemistry graduates. Such graduates have completed a curriculum certified by CPT and are eligible immediately for ACS membership.

In the latest report Yale University retains its status as the largest producer of M.S. chemists with 41 such graduates, well ahead of Cornell University and Harvard University that share second place with 27 each.

Texas A&M leads in production of new B.S. chemical engineers with 166 such graduates in 1980–81. And Massachusetts Institute of Technology is the largest producer of graduate chemical engineers with 63 at the M.S. level and 15 at the Ph.D. level.

Michael Heylin, Washington

These schools had the most chemistry graduates, 1980–81

Total B.S. graduates

1. U of North Carolina, Chapel Hill	156
2. Indiana U	132
3. U of California, Los Angeles	126
4. U of Pittsburgh	103
5. Emory U	102
6. U of Illinois, Urbana-Champaign	94
7. U of South Florida	93
8. Duke U	90
9. Rutgers U, New Brunswick	85
10. U of Miami	81
11. Miami U	80
12. U of Florida	79
13. U of California, San Diego	78
14. U of Maryland	77
15. U of Washington	73
16. U of Colorado, Boulder	69
17. U of Michigan, Ann Arbor	67
18. U of Virginia	63
19. State U of New York, Stony Brook	59
20. U of Puerto Rico, Rio Pedras	57
21. U of California, Berkeley	55
22. Case Western Reserve U	54
22. U of Georgia	54
24. Creighton U	53
25. U of Texas, Austin	52
25. Valparaiso U	52
25. West Virginia U	52

Certified B.S. graduates

1. U of California, San Diego	78
2. U of Michigan, Ann Arbor	67
3. Rutgers U, New Brunswick	63
4. U of Pittsburgh	57
5. U of California, Berkeley	54
6. U of Texas, Austin	52
6. U of Washington	52
8. U of North Carolina, Chapel Hill	49
9. Massachusetts Inst. of Tech	47
10. U of California, Los Angeles	39
10. Cornell U	39
12. U of Cincinnati	38
13. U of Colorado, Boulder	37
14. Carnegie-Mellon U	36
14. U of Illinois, Urbana-Champaign	36
14. Rensselaer Polytechnic Inst.	36
17. Lehigh U	35
18. Illinois State U	31
18. Texas A&M	31
20. U.S. Naval Academy	30
21. Indiana U	29
22. Boston C	28
22. U of South Florida	28
22. State U of New York, Albany	28
25. Northwestern U	27
25. U of Puerto Rico, Mayaguez	27

M.S. graduates

1. Yale U	41
2. Cornell U	27
2. Harvard U	27
4. Columbia U	23
5. U of Michigan, Ann Arbor	21
5. Purdue U	21
7. U of California, Berkeley	20
7. U of Illinois, Urbana-Champaign	20
9. Ohio State U	19
10. U of Cincinnati	18
11. Johns Hopkins U	17
11. Northwestern U	17
13. U of California, Los Angeles	16
13. Morehouse C[a]	16
15. U of Pittsburgh	15
16. U of California, San Diego	14
16. U of Illinois, Chicago Circle	14
16. North Texas State U	14
16. Seton Hall U	14
16. Texas A&M U	14
16. Wayne State U	14
22. New York U	13
22. Princeton U	13
22. Rutgers U, Newark C of Arts & Sci	13
22. U of Texas, Dallas	13
22. U of Wisconsin, Madison	13

Ph.D. graduates

1. U of Illinois, Urbana-Champaign	73
2. U of California, Berkeley	45
3. Purdue U	39
4. California Inst. of Tech	36
4. Massachusetts Inst. of Tech	36
6. Ohio State U	31
7. U of California, San Diego	30
7. Indiana U	30
9. U of Wisconsin, Madison	28
10. U of North Carolina, Chapel Hill	27
11. Iowa State U of Science & Tech	26
11. Michigan State U	26
13. Northwestern U	25
14. U of California, Davis	24
14. Cornell U	24
14. U of Southern California	24
17. Pennsylvania State U	23
18. U of California, Los Angeles	22
18. Columbia U	22
20. U of Nebraska, Lincoln	21
20. U of Washington	21
22. Texas A&M U	20
22. U of Texas, Austin	20
24. U of Georgia	19
24. U of Pittsburgh	19

[a] Master's degrees given by Atlanta U.

ACS Committee on Professional Training 1981 annual report

Summary of data from approved programs, 1977–81

	Bachelors				Masters		Doctorates	
	Number of schools	Graduates (total)	Certified graduates	Non-certified graduates	Number of schools	Grad-uates	Number of schools	Grad-uates
CHEMISTRY								
1977	534	10,207	4219	5988	321	1688	189	1563
1978	547	10,350	4285	6065	323	1798	189	1532
1979	551	10,451	4424	6027	323	1716	188	1532
1980	554	10,170	4170	6000	324	1698	188	1561
1981	558	10,453	4337	6116	323	1609	187	1613
CHEMICAL ENGINEERING[a]								
1977	120	—	3282	—	115	1095	103	298
1978	119	—	4225	—	114	1109	98	251
1979	112	—	4977	—	107	951	92	237
1980	109	—	5348	—	105	974	88	243
1981	110	—	5831	—	106	1020	87	250

a Chemical engineering departments are not required to report their data to CPT, so the number of departments included in this category varies from year to year. **Note:** Bachelor's degree projections for 1982: 558 chemistry departments report that they expect a total of 9509 bachelor graduates with majors in chemistry during the 1981–82 academic year, and 110 chemical engineering departments report that they expect a total of 6472 bachelor graduates with majors in chemical engineering.

The number of bachelor's degree graduates in chemistry from schools whose undergraduate chemistry programs are approved by ACS increased almost 3% in 1980–81 from the previous year, back approximately to the number of graduates in 1979. The number of master's degrees from these departments again decreased, this year 5%, and the number of Ph.D. degrees continued to rise for the second year in a row, this year 3%.

The percentage of baccalaureate graduates certified to ACS continued at the 41% level. (Certified graduates are those who have completed the curriculum specified by CPT and are eligible for full membership in ACS; noncertified graduates may become associate members of ACS upon graduation and full members after three years of professional experience or a higher degree in a chemical science.)

Total numbers of bachelor's degrees (certified and noncertified), master's degrees, and Ph.D. degrees awarded in 1980–81 by departments whose chemistry programs are ACS approved are listed by institution in the large table at the end of this report and are summarized in the two smaller tables. These tables also include numbers of chemical engineering graduates from institutions whose programs are accredited by the American Institute of Chemical Engineers and the Accreditation Board for Engineering & Technology. (Note: These departments are not required to report their data to CPT, so the number of departments included in this listing varies from year to year.)

The number of bachelor's degrees in chemical engineering from the 110 AIChE-ABET-accredited departments that reported in 1981 increased 9% from the total reported by 109 departments in 1980. These 110 departments reported an expected further increase of 11% in 1982. During the five-year period from 1977 to 1981, the number of reported bachelor's degree graduates in chemical engineering increased 78%. At the graduate level, the number of chemical engineering master's degrees reported in 1981 rose 5% from the year before, and the number of Ph.D. degrees reported rose 3%.

Summary of totals from 1981 reports from approved programs

	Schools reporting	Men	Women	Total
CHEMISTRY				
Bachelors, total	558			10,453
Certified		3114	1223	4,337
Noncertified		4311	1805	6,116
Masters	323	1158	451	1,609
Doctorates	187	1358	255	1,613
CHEMICAL ENGINEERING				
Bachelors, certified	110	4644	1187	5,831
Masters	106	888	132	1,020
Doctorates	87	239	11	250

Programs at ACS-approved departments normally are re-evaluated at five-year intervals. There were 559 colleges and universities on the approved list at the end of 1981. The committee studied the chemistry programs at 150 of them during the year. Each re-evaluation involved a review of extensive documentary materials submitted by the department head describing the current status of the program. During 1981, four chemistry programs were newly approved by the committee, four approved programs were put on probation, four were removed from probation, and two were removed from the approved list.

The committee continued during the year its work in revising the criteria used to evaluate undergraduate programs in chemistry. A very suc-

Committee members, 1981

J. Arthur Campbell, *chairman*
Harvey Mudd College
Henry A. Bent, *acting chairman, September to December 1981*
North Carolina State University
Alice J. Cunningham
Agnes Scott College
Ernest L. Eliel
University of North Carolina, Chapel Hill
Patricia A. M. Figueras
Eastman Kodak Research Labs
Harry B. Gray
California Institute of Technology
C. David Gutsche
Washington University
Donald E. Jones
Western Maryland College
Peter Lykos
Illinois Institute of Technology
Eli M. Pearce
Polytechnic Institute of New York
Melvin B. Robin
Bell Telephone Laboratories
Jere P. Segrest
University of Alabama, Birmingham
Harry S. Mosher, *consultant*
Stanford University
Bonnie R. Blaser, *secretary*
Nancy B. Jackson, *staff associate, January to July 1981*
Mairin B. Brennan, *staff associate, July to December 1981*
American Chemical Society

cessful meeting at which representatives of the ACS divisions were invited to discuss their suggestions for the revision was held at the ACS national meeting in Atlanta in March 1981, and an open meeting to which representatives of all ACS-approved departments and other interested members were invited was held at the ACS national meeting in New York City in August. Plans for 1982 include sending a draft copy of the revision to all ACS-approved departments, ACS divisions, and committee Visiting Associates prior to the committee's open meeting in Las Vegas in March.

On July 1, the committee, with the concurrence of the ACS Board of Directors, withdrew from membership in the Council on Postsecondary Accreditation (see C&EN, July 13, 1981, page 23, for more detailed information on this subject.) Prior to that action, the ACS-approved schools were surveyed concerning their thoughts on the proposed withdrawal, and during the three weeks within which responses were to be sent to the committee, 453 (81%) of the 560 approved schools responded. Of these, 419 (92%) agreed that CPT should withdraw from COPA membership.

The 1981 edition of the biennial ACS Directory of Graduate Research was published in October and included for the first time those departments at the master's degree level whose undergraduate programs are ACS approved and which require a master's thesis. The number of pages in this edition of the directory increased 16% (as opposed to 11% increases for the three preceding editions), the number of departments listed increased 22% (to 647), the number of faculty members 13% (to 10,775), and the number of research publication citations 12% (to 54,412). The average number of research publications per faculty member changed from 5.14 in the 1979 edition to 5.05 in the current volume.

Funding was obtained by the committee for constructing a Subject Index for the Chemical Sciences: a proposed, compact, computerized data base of the names and research interests of faculty members included in the Directory of Graduate Research, beginning with the 1983 edition. The data base will be arranged in a hierarchical way so that it can be searched to yield information on faculty members who have expressed interest in any broad subject, or, on a reduced scope, to identify those with interests in exceedingly narrow disciplines. Because the data base will be built on faculty lists in the directory, it will serve as a multilevel concordance for this volume.

To determine why chemistry faculty members leave for other positions, especially nonacademic ones, the committee conducted a survey in 1980 on faculty mobility in the past 10 years (1970–79) in the ACS-approved departments. A report of this study was published in C&EN, Feb. 16, 1981, page 28. To identify trends, a followup survey was completed for the 1980 calendar year. A report on the results of this survey and comparisons with the previous study will be published in 1982.

The committee also conducted surveys in 1981 on the use of computers in undergraduate chemistry programs and on the language requirements in graduate programs in chemistry. Reports on these also will be prepared and published in 1982.

Chemistry and chemical engineering degrees awarded by approved schools, 1980–81

	CHEMISTRY				CHEMICAL ENGINEERING		
	Bachelor's, certified						
	Yes	No	M.S.	Ph.D.	B.S.	M.S.	Ph.D.
Abilene Christian U	11	3	1	—	—	—	—
Adelphi U	1	5	5	—	—	—	—
Agnes Scott C	5	2	—	—	—	—	—
Akron, U of	10	5	8	5	(a)	—	—
Alabama, U of							
University	5	17	2	3	30	6	0
Birmingham	4	23	3	2	—	—	—
Huntsville	3	2	4	—	—	—	—
Alaska, U of	3	1	0	—	—	—	—
Albion C	2	16	—	—	—	—	—
Albright C	6	18	—	—	—	—	—
Alfred U	7	0	—	—	—	—	—
Allegheny C	4	27	—	—	—	—	—
Alma C	1	9	—	—	—	—	—
American U	3	0	6	7	—	—	—
Amherst C	8	4	—	—	—	—	—
Andrews U	6	6	—	—	—	—	—
Appalachian State U	7	10	0	—	—	—	—
Arizona State U	24	14	3	9	42	3	0
Arizona, U of	16	17	11	9	35	6	0
Arkansas, U of							
Fayetteville	7	23	1	9	53	5	0
Little Rock	3	5	0	—	—	—	—
Ashland C	1	3	—	—	—	—	—
Auburn U	9	33	3	4	60	7	0
Augsburg C	3	8	—	—	—	—	—
Augustana C (Illinois)	1	11	—	—	—	—	—
Augustana C (South Dakota)	0	7	—	—	—	—	—
Austin C	2	8	—	—	—	—	—
Baldwin-Wallace C	2	10	—	—	—	—	—
Ball State U	13	1	5	—	—	—	—
Barnard C	0	15	—	—	—	—	—
Bates C	10	6	—	—	—	—	—
Baylor U	13	20	0	1	—	—	—
Beloit C	0	7	—	—	—	—	—
Bemidji State U	1	6	—	—	—	—	—
Birmingham-Southern C	2	16	—	—	—	—	—
Bloomsburg State C	1	2	—	—	—	—	—
Boston C	28	6	4	4	—	—	—
Boston U	5	24	3	4	—	—	—
Bowdoin C	5	31	—	—	—	—	—
Bowling Green State U	6	19	9	—	—	—	—
Bradley U	3	9	4	—	—	—	—
Brandeis U	0	27	9	5	—	—	—
Bridgeport, U of	7	1	1	—	—	—	—
Bridgewater State C	1	11	3	—	—	—	—
Brigham Young U	26	13	4	2	34	9	5
Brown U	4	36	0	12	—	—	—
Bryn Mawr C	14	0	1	1	—	—	—
Bucknell U	10	13	0	—	35	1	—
Butler U	2	12	4	—	—	—	—
California Institute of Tech	5	12	2	36	16	8	7
California Polytechnic State U	13	21	5	—	—	—	—
California State C							
Bakersfield	3	0	—	—	—	—	—
San Bernardino	1	6	—	—	—	—	—
Stanislaus	5	3	—	—	—	—	—
California State Polytechnic U	10	2	6	—	(e)	—	—
California State U							
Chico	1	8	—	—	—	—	—
Dominguez Hills	4	6	—	—	—	—	—
Fresno	1	5	4	—	—	—	—
Fullerton	15	21	4	—	—	—	—
Hayward	14	14	4	—	—	—	—
Long Beach	9	30	7	—	31	—	—
Los Angeles	19	0	5	—	—	—	—
Northridge	9	7	4	—	—	—	—
Sacramento	7	13	2	—	—	—	—

	CHEMISTRY				CHEMICAL ENGINEERING		
	Bachelor's, certified						
	Yes	No	M.S.	Ph.D.	B.S.	M.S.	Ph.D.
California, U of							
Berkeley	54	1	20	45	102	19	12
Davis	19	6	10	24	45	10	2
Irvine	10	36	6	11	—	—	—
Los Angeles	39	87	16	22	—	—	—
Riverside	5	2	7	9	—	—	—
San Diego	78	0	14	30	—	—	—
Santa Barbara	19	5	9	14	24	11	3
Santa Cruz	9	12	5	6	—	—	—
Calvin C	7	3	—	—	—	—	—
Canisius C	7	0	—	—	—	—	—
Capital U	2	8	—	—	—	—	—
Carleton C	2	27	—	—	—	—	—
Carnegie-Mellon U	36	3	5	6	64	21	7
Carroll C	5	11	—	—	—	—	—
Carthage C	3	4	—	—	—	—	—
Case Western Reserve U	11	43	7	4	50	16	1
Catholic U of America	3	1	3	2	12	1	0
Centenary C of Louisiana	1	4	—	—	—	—	—
Central C	0	6	—	—	—	—	—
Central Connecticut State C	13	2	1	—	—	—	—
Central Florida, U of	11	0	2	—	—	—	—
Central Michigan U	2	23	2	—	—	—	—
Central State U							
Wilberforce, Ohio	6	2	—	—	—	—	—
Edmond, Okla.	1	16	—	—	—	—	—
Charleston, C of	7	3	—	—	—	—	—
Chatham C	1	2	—	—	—	—	—
Chestnut Hill C[b]							
Chicago, U of	11	15	5	15	—	—	—
Cincinnati, U of	38	0	18	18	79	17	2
Citadel, The	3	10	—	—	—	—	—
City U of New York—							
Graduate Center				13			
Brooklyn C	1	49	0	—	—	—	—
City C	0	22	2	—	(a)	—	—
Herbert H. Lehman C	5	1	—	—	—	—	—
Hunter C	3	0	0	—	—	—	—
Queens C	8	14	1	—	—	—	—
Clarion State C	3	3	—	—	—	—	—
Clark U	12	0	0	3	—	—	—
Clarkson C of Tech	14	0	7	2	95	14	2
Clemson U	8	2	3	4	53	2	2
Cleveland State U	17	0	10	3	33	5	0
Coe C	0	8	—	—	—	—	—
Colby C	4	8	—	—	—	—	—
Colgate U	1	7	—	—	—	—	—
Colorado C	9	8	—	—	—	—	—
Colorado School of Mines	3	0	11	3	71	10	8
Colorado State U	17	11	5	17	—	—	—
Colorado, U of							
Boulder	37	32	12	16	71	12	1
Denver	3	8	2	—	—	—	—
Columbia U	7	39	23	22	(a)	—	—
Concordia C	2	9	—	—	—	—	—
Connecticut, U of	11	24	7	4	55	16	5
Cooper Union[c]					25	5	—
Cornell C	0	15	—	—	—	—	—
Cornell U	39	0	27	24	62	12	1
Creighton U	2	51	3	—	—	—	—
Dartmouth C	0	21	5	3	—	—	—
David Lipscomb C	2	11	—	—	—	—	—
Davidson C	9	1	—	—	—	—	—
Dayton, U of	7	4	3	—	40	8	—
Delaware State C	0	1	—	—	—	—	—
Delaware, U of	26	21	7	5	57	13	7
Delaware Valley C of Science & Agriculture	2	2	—	—	—	—	—
Delta State U	3	10	0	—	—	—	—
Denison U	0	11	—	—	—	—	—
Denver, U of	4	5	3	1	—	—	—
De Paul U	1	2	2	—	—	—	—
DePauw U	3	5	—	—	—	—	—
Detroit, U of	5	4	3	3	(a)	—	—
Dickinson C	3	17	—	—	—	—	—
Drake U	2	3	1	—	—	—	—
Drew U	2	7	—	—	—	—	—
Drexel U	15	4	7	4	81	10	1
Duke U	16	74	1	15	—	—	—
Duquesne U	5	4	12	2	—	—	—
Earlham C	1	13	—	—	—	—	—
East Carolina U	5	7	4	—	—	—	—
East Stroudsburg State C	4	19	2	—	—	—	—
East Tennessee State U	3	6	0	—	—	—	—
East Texas State U	5	2	3	—	—	—	—
Eastern Illinois U	11	3	2	—	—	—	—
Eastern Kentucky U	4	8	2	—	—	—	—
Eastern Michigan U	1	20	12	—	—	—	—
Elizabethtown C	1	15	—	—	—	—	—
Elmhurst C	4	13	—	—	—	—	—
Emory U	7	95	12	10	—	—	—
Emporia State U	5	3	2	—	—	—	—
Evansville, U of	3	9	—	—	—	—	—
Fairfield U	11	13	—	—	—	—	—
Fairleigh Dickinson U							
Rutherford	1	1	3	—	—	—	—
Teaneck	19	1	2	—	—	—	—
Fisk U	13	0	3	—	—	—	—
Florida Atlantic U	4	19	2	0	—	—	—
Florida State U	4	30	7	12	—	—	—
Florida, U of	6	73	3	12	51	6	3
Fordham U	7	14	0	4	—	—	—
Fort Lewis C	1	9	—	—	—	—	—
Franklin and Marshall C	15	6	—	—	—	—	—
Furman U	10	12	2	—	—	—	—
Geneva C	4	4	—	—	—	—	—
George Mason U	14	11	—	—	—	—	—
George Washington U	5	8	3	0	—	—	—
Georgetown U	19	0	9	9	—	—	—
Georgia Institute of Tech	15	0	9	9	137	19	1
Georgia State U	3	8	2	—	—	—	—
Georgia, U of	3	51	12	19	—	—	—
Gettysburg C	9	9	—	—	—	—	—
Glassboro State C	5	2	—	—	—	—	—
Gonzaga U	1	3	—	—	—	—	—
Goucher C	1	11	—	—	—	—	—
Grand Valley State C	1	6	—	—	—	—	—
Grinnell C	2	15	—	—	—	—	—
Gustavus Adolphus C	8	16	—	—	—	—	—
Hamilton C	0	11	—	—	—	—	—
Hamline U	4	5	—	—	—	—	—
Hampden-Sydney C	11	2	—	—	—	—	—
Hampton Institute	1	3	—	—	—	—	—
Hartford, U of	7	2	0	—	—	—	—
Hartwick C	3	1	—	—	—	—	—
Harvard U	0	26	27	17	—	—	—
Harvey Mudd C	16	0	—	—	—	—	—
Haverford C	15	5	—	—	—	—	—
Hawaii, U of	14	4	3	8	—	—	—
Hiram C	2	12	—	—	—	—	—
Hobart and William Smith C	1	15	—	—	—	—	—
Hofstra U	10	4	—	—	—	—	—
Hollins C	0	0	—	—	—	—	—
Holy Cross, C of the	25	15	1	—	—	—	—
Hope C	13	24	—	—	—	—	—
Houston, U of	14	3	1	7	29	12	7
Howard U	1	36	6	8	23	—	—
Humboldt State U	5	3	—	—	—	—	—
Idaho State U	0	6	1	—	—	—	—
Idaho, U of	6	2	7	3	18	7	1
Illinois Benedictine C	10	0	—	—	—	—	—
Illinois Institute of Tech	5	0	2	2	(a)	—	—
Illinois State U	31	2	9	—	—	—	—
Illinois, U of							
Chicago Circle	22	29	14	9	(a)	—	—
Urbana-Champaign	36	58	20	73	94	16	10
Illinois Wesleyan U	0	5	—	—	—	—	—
Indiana State U	2	2	3	—	—	—	—
Indiana U	29	103	9	30	—	—	—
Indiana U of Pennsylvania	12	2	4	—	—	—	—
Indiana U, South Bend	2	7	—	—	—	—	—
Indiana U-Purdue U							
Fort Wayne	2	4	—	—	—	—	—
Indianapolis	2	24	4	—	—	—	—

	CHEMISTRY Bachelor's, certified				CHEMICAL ENGINEERING		
	Yes	No	M.S.	Ph.D.	B.S.	M.S.	Ph.D.
Iowa State U of Science & Tech	7	7	7	26	75	10	2
Iowa, U of	9	3	9	6	20	2	2
Ithaca C	5	3	—	—	—	—	—
Jackson State U	2	4	6	—	—	—	—
James Madison U	4	15	—	—	—	—	—
John Carroll U	4	20	2	—	—	—	—
Johns Hopkins U	17	0	17	12	—	—	—
Juniata C	7	20	—	—	—	—	—
Kalamazoo C	3	17	—	—	—	—	—
Kansas State U	3	4	5	6	25	6	3
Kansas, U of	12	23	2	7	37	7	3
Kearney State C	1	2	—	—	—	—	—
Kent State U	10	12	2	4	—	—	—
Kentucky, U of	11	14	5	4	47	13	2
Kenyon C	8	5	—	—	—	—	—
King's C	5	0	—	—	—	—	—
Knox C	6	20	—	—	—	—	—
Lafayette C	1	13	—	—	46	—	—
Lake Forest C	0	3	—	—	—	—	—
Lamar U	15	3	1	—	33	11	0
La Salle C	7	2	—	—	—	—	—
Lawrence U	1	9	11	4	—	—	—
Lebanon Valley C	10	2	—	—	—	—	—
Lehigh U	35	0	12	6	96	18	4
Le Moyne C	16	0	—	—	—	—	—
Lincoln U	0	7	—	—	—	—	—
Long Island U							
Conolly C	3	7	6	—	—	—	—
C. W. Post C	6	2	—	—	—	—	—
Loras C	4	9	—	—	—	—	—
Louisiana State U							
Baton Rouge	5	5	2	6	76	11	6
Shreveport	4	0	—	—	—	—	—
Louisiana Tech U	0	4	1	—	22	2	—
Louisville U of	5	18	1	2	—	25	1
Lowell, U of	6	0	6	2	28	1	—
Loyola C	13	0	—	—	—	—	—
Loyola Marymount U	3	1	—	—	—	—	—
Loyola U	0	0	—	—	—	—	—
Loyola U of Chicago	16	19	5	1	—	—	—
Luther C	1	9	—	—	—	—	—
Macalester C	1	12	—	—	—	—	—
MacMurray C	1	5	—	—	—	—	—
Maine, U of	3	4	4	0	48	4	0
Manhattan C[d]	16	7	—	—	60	36	—
Manhattanville C	3	1	—	—	—	—	—
Mankato State U	2	9	2	—	—	—	—
Marietta C	7	1	—	—	—	—	—
Marist C	4	3	—	—	—	—	—
Marquette U	13	0	5	2	—	—	—
Marshall U	2	12	4	—	—	—	—
Maryland, U of	8	69	4	7	66	7	2
Maryland Baltimore County, U of	5	7	0	0	—	—	—
Massachusetts Institute of Tech	47	0	1	36	117	63	15
Massachusetts, U of	20	6	9	13	46	8	1
McMurry C	1	6	—	—	—	—	—
McNeese State U	1	0	0	—	—	—	—
Memphis State U	1	15	2	1	—	—	—
Merrimack C	10	0	—	—	—	—	—
Metropolitan State C	17	11	—	—	—	—	—
Miami U	19	61	6	4	—	—	—
Miami, U of	8	73	1	2	—	—	—
Michigan State U	24	17	7	26	81	13	2
Michigan Tech U	8	0	3	1	88	2	—
Michigan, U of							
Ann Arbor	67	0	21	18	111	10	5
Dearborn	10	8	—	—	—	—	—
Flint	1	8	—	—	—	—	—
Middle Tennessee State U	2	27	3	—	—	—	—
Middlebury C	1	8	0	—	—	—	—
Midwestern State U	6	4	—	—	—	—	—
Millersville State C	3	4	—	—	—	—	—
Millsaps C	6	20	—	—	—	—	—

	CHEMISTRY Bachelor's, certified				CHEMICAL ENGINEERING		
	Yes	No	M.S.	Ph.D.	B.S.	M.S.	Ph.D.
Minnesota, U of							
Minneapolis	26	0	6	15	(a)	—	—
Duluth	11	12	2	—	—	—	—
Mississippi C	0	12	—	—	—	—	—
Mississippi State U	1	6	4	0	44	3	0
Mississippi, U of	2	39	1	1	13	2	0
Missouri, U of							
Columbia	10	13	6	1	65	16	0
Kansas City	6	22	0	1	—	—	—
Rolla	9	2	8	4	98	14	2
St. Louis	11	13	3	2	—	—	—
Monmouth C	0	6	—	—	—	—	—
Montana C of Mineral Science & Tech	1	2	0	—	—	—	—
Montana State U	2	7	2	1	52	3	0
Montana, U of	3	9	4	0	—	—	—
Montclair State C	9	14	6	—	—	—	—
Moorhead State U	1	1	—	—	—	—	—
Moravian C	2	3	—	—	—	—	—
Morehouse C[e]	0	4	16	—	—	—	—
Morgan State U	1	7	—	—	—	—	—
Mount Holyoke C	0	11	1	0	—	—	—
Mount Saint Vincent, C of[d]	1	1	—	—	—	—	—
Muhlenberg C	3	18	—	—	—	—	—
Murray State U	3	14	3	—	—	—	—
Muskingum C	0	17	—	—	—	—	—
Nebraska, U of							
Lincoln	6	7	3	21	32	8	0
Omaha	3	7	—	—	—	—	—
Nebraska Wesleyan U	4	1	—	—	—	—	—
Nevada, U of							
Las Vegas	3	9	—	—	—	—	—
Reno	0	3	1	1	—	—	—
New Hampshire, U of	6	5	2	7	31	5	1
New Jersey Institute of Tech[c]					96	23	3
New Mexico Highlands U	0	1	0	—	—	—	—
New Mexico Institute of Mining & Tech	2	3	2	—	—	—	—
New Mexico State U	5	9	1	4	30	4	—
New Mexico, U of	9	2	12	9	(a)	—	—
New Orleans, U of	1	8	0	8	—	—	—
New York U	18	14	13	6	—	—	—
North Alabama, U of	11	1	—	—	—	—	—
North Carolina A&T State U	6	1	2	—	—	—	—
North Carolina Central U	0	6	2	—	—	—	—
North Carolina State U	10	5	0	3	(a)	—	—
North Carolina, U of							
Asheville	2	3	—	—	—	—	—
Chapel Hill	49	107	6	27	—	—	—
Charlotte	5	12	4	—	—	—	—
Greensboro	9	7	5	—	—	—	—
Wilmington	7	6	—	—	—	—	—
North Dakota State U	0	10	4	2	—	—	—
North Dakota, U of	3	6	3	5	24	4	—
North Texas State U	0	16	14	10	—	—	—
Northeast Louisiana U	2	0	1	—	—	—	—
Northeastern U	10	1	7	9	(a)	—	—
Northern Arizona U	3	39	2	—	—	—	—
Northern Colorado, U of	4	6	3	—	—	—	—
Northern Illinois U	13	12	5	0	—	—	—
Northern Iowa, U of	3	12	4	—	—	—	—
Northern Michigan U	3	8	0	—	—	—	—
Northwest Missouri State U	3	2	—	—	—	—	—
Northwestern State U of Louisiana	0	0	0	—	—	—	—
Northwestern U	27	21	17	25	62	19	5
Norwich U	3	0	—	—	—	—	—
Notre Dame, U of	10	14	5	5	66	9	3
Oakland U	12	18	2	—	—	—	—
Oberlin C	1	18	—	—	—	—	—
Occidental C	4	14	—	—	—	—	—
Ohio Northern U	0	7	—	—	—	—	—
Ohio State U	26	0	19	31	63	15	2
Ohio U	9	13	2	3	21	3	—
Ohio Wesleyan U	1	11	—	—	—	—	—
Oklahoma State U	8	13	0	5	52	13	2
Oklahoma, U of	8	23	11	5	51	9	7

	CHEMISTRY				CHEMICAL ENGINEERING		
	Bachelor's, certified Yes	Bachelor's, certified No	M.S.	Ph.D.	B.S.	M.S.	Ph.D.
Old Dominion U	5	8	9	—	—	—	—
Oregon State U	10	0	7	16	52	9	2
Oregon, U of	7	19	4	6	—	—	—
Pace U	2	3	—	—	—	—	—
Pacific Lutheran U	0	15	—	—	—	—	—
Pacific, U of The	2	25	0	1	—	—	—
Pennsylvania State U	24	25	10	23	145	9	4
Pennsylvania, U of	6	26	0	18	38	10	7
Philadelphia C of Pharmacy & Science	9	0	3	0	—	—	—
Philadelphia C of Textiles & Science	7	5	—	—	—	—	—
Pittsburg State U	2	6	1	—	—	—	—
Pittsburgh, U of	57	46	15	19	95	12	6
Polytechnic Institute of New York	7	0	7	8	33	10	2
Pomona C	4	5	—	—	—	—	—
Portland State U	5	8	2	0	—	—	—
Pratt U[c]					14	—	—
Princeton U	24	2	13	16	35	3	7
Providence C	2	2	0	0	—	—	—
Puerto Rico, U of							
Mayaguez	27	3	6	—	78	1	—
Rio Piedras	14	43	2	4	—	—	—
Puget Sound, U of	4	7	1	—	—	—	—
Purdue U	25	15	21	39	133	19	10
Purdue U, Calumet	0	0	—	—	—	—	—
Randolph-Macon Woman's C	2	3	—	—	—	—	—
Redlands, U of	3	0	—	—	—	—	—
Reed C	17	2	—	—	—	—	—
Regis C	0	3	—	—	—	—	—
Rensselaer Polytechnic Institute	36	0	7	8	117	15	1
Rhode Island, U of	5	8	5	1	20	7	2
Rice U	11	3	1	4	(a)	—	—
Richmond, U of	2	22	0	—	—	—	—
Rider C	9	0	—	—	—	—	—
Ripon C	4	3	—	—	—	—	—
Roanoke C	4	4	—	—	—	—	—
Rochester Institute of Tech	6	0	3	—	—	—	—
Rochester, U of	7	12	8	10	37	4	1
Rollins C	1	0	—	—	—	—	—
Roosevelt U	7	1	5	—	—	—	—
Rose-Hulman Institute of Tech	5	0	—	—	72	0	—
Russell Sage C	7	1	—	—	—	—	—
Rutgers U							
New Brunswick	63	22	10	8	(a)	—	—
Newark C of Arts & Sciences	19	13	13	6	—	—	—
Saginaw Valley State C	6	9	—	—	—	—	—
St. Anselm's C	2	4	—	—	—	—	—
St. Cloud State U	3	6	—	—	—	—	—
St. John Fisher C	13	2	—	—	—	—	—
St. John's U	6	2	5	1	—	—	—
St. Joseph C	0	1	8	—	—	—	—
St. Joseph's U	9	16	8	—	—	—	—
St. Lawrence U	10	18	—	—	—	—	—
St. Louis U	2	40	3	—	—	—	—
St. Mary's C	0	9	—	—	—	—	—
St. Olaf C	6	36	—	—	—	—	—
St. Peter's C	2	5	—	—	—	—	—
St. Thomas, C of	6	6	—	—	—	—	—
Sam Houston State U	7	1	6	—	—	—	—
San Diego State U	20	0	10	2	—	—	—
San Francisco State U	7	37	7	—	—	—	—
San Francisco, U of	3	3	5	—	—	—	—
San Jose State U	20	15	10	—	19	9	—
Santa Clara, U of	10	6	—	—	—	—	—
Scranton, U of	5	26	11	—	—	—	—
Seattle U	1	3	—	—	—	—	—
Seton Hall U	11	3	14	8	—	—	—
Shippensburg State C	7	5	0	—	—	—	—
Siena C	7	1	—	—	—	—	—
Simmons C	4	3	—	—	—	—	—
Skidmore C	2	9	—	—	—	—	—

	CHEMISTRY				CHEMICAL ENGINEERING		
	Bachelor's, certified Yes	Bachelor's, certified No	M.S.	Ph.D.	B.S.	M.S.	Ph.D.
Slippery Rock State C	6	1	—	—	—	—	—
Smith C	5	1	0	1	—	—	—
Sonoma State U	0	7	—	—	—	—	—
South Carolina, U of	8	22	5	15	33	2	0
South Dakota School of Mines & Tech	5	0	1	—	36	2	—
South Dakota State U	1	29	3	—	—	—	—
South Dakota, U of	8	13	1	—	—	—	—
South Florida, U of	28	65	3	1	(a)	—	—
Southeast Missouri State U	1	7	3	—	—	—	—
Southeastern Massachusetts U	10	4	1	—	—	—	—
Southern California, U of	13	9	3	24	(a)	—	—
Southern Illinois U							
Carbondale	4	17	6	4	—	—	—
Edwardsville	8	15	7	—	—	—	—
Southern Methodist U	8	13	0	—	—	—	—
Southern Mississippi, U of	7	6	3	1	—	—	—
Southern Oregon State C	2	2	—	—	—	—	—
Southern U and A&M C	7	0	2	—	—	—	—
Southwest Missouri State U	2	21	—	—	—	—	—
Southwest State U	4	6	—	—	—	—	—
Southwest Texas U	5	0	3	—	—	—	—
Southwestern at Memphis	10	6	—	—	—	—	—
Southwestern Louisiana, U of	1	17	1	—	14	2	—
Southwestern Oklahoma State U	10	13	—	—	—	—	—
Stanford U	17	10	0	17	19	14	7
State U of New York							
Albany	28	3	6	4	—	—	—
Binghamton	10	33	6	2	—	—	—
Buffalo	14	13	3	11	100	7	7
Stony Brook	24	35	5	7	—	—	—
C at Brockport	3	8	—	—	—	—	—
C at Buffalo	16	1	2	—	—	—	—
C at Cortland	4	6	—	—	—	—	—
C at Fredonia	5	10	2	—	—	—	—
C at Geneseo	3	2	1	—	—	—	—
C at New Paltz	10	1	3	—	—	—	—
C at Oneonta	1	20	2	—	—	—	—
C at Oswego	13	2	3	—	—	—	—
C at Plattsburgh	6	17	3	—	—	—	—
C at Potsdam	7	13	—	—	—	—	—
Stephen F. Austin State U	2	6	2	—	—	—	—
Stetson U	2	6	—	—	—	—	—
Stevens Institute of Tech	6	5	10	3	—	—	—
Suffolk U	2	0	—	—	—	—	—
Susquehanna U	4	1	—	—	—	—	—
Swarthmore C	2	8	—	—	—	—	—
Syracuse U	11	6	3	3	(a)	—	—
Temple U	11	11	4	4	—	—	—
Tennessee Tech U	5	14	1	—	24	1	0
Tennessee, U of							
Knoxville	8	12	4	11	79	12	5
Chattanooga	14	25	—	—	—	—	—
Martin	1	7	—	—	—	—	—
Texas A&I U	6	1	2	—	28	8	—
Texas A&M U	31	6	14	20	166	10	0
Texas Christian U	1	8	0	4	—	—	—
Texas Southern U	21	0	4	—	—	—	—
Texas Tech U	18	16	7	8	(a)	—	—
Texas U of							
Arlington	7	19	2	—	—	—	—
Austin	52	0	12	20	107	23	3
Dallas	7	0	13	—	—	—	—
El Paso	8	0	5	—	—	—	—
Texas Woman's U	0	3	3	1	—	—	—
Thiel C	2	8	—	—	—	—	—
Thomas More C	4	3	—	—	—	—	—
Toledo, U of	1	17	3	0	24	9	2
Towson State U	11	3	—	—	—	—	—
Trenton State C	10	0	—	—	—	—	—
Trinity C	11	15	0	—	—		
Trinity U	0	6	0	—	—		
Tri-State U[c]					(a)	—	—
Tufts U	0	48	4	1	37	11	2
Tulane U of Louisiana	3	10	1	1	(a)	—	—

	CHEMISTRY				CHEMICAL ENGINEERING		
	Bachelor's, certified						
	Yes	No	M.S.	Ph.D.	B.S.	M.S.	Ph.D.
Tulsa, U of	2	0	—	—	25	4	3
Tuskegee Institute	0	9	2	—	—	—	—
Union C	2	15	0	—	—	—	—
U.S. Air Force Academy	8	4	—	—	—	—	—
U.S. Naval Academy	30	0	—	—	—	—	—
Ursinus C	4	16	—	—	—	—	—
Utah State U	5	0	3	1	—	—	—
Utah, U of	3	33	6	14	(a)	—	—
Valparaiso U	4	48	—	—			
Vanderbilt U	1	33	2	6	40	0	0
Vassar C	0	7	0	—	—	—	—
Vermont, U of	22	0	2	4	—	—	—
Villanova U	12	0	4	2	38	3	—
Virginia Commonwealth U	8	21	1	2	—	—	—
Virginia Military Institute	10	0	—	—	—	—	—
Virginia Polytechnic Institute & State U	9	15	10	15	85	0	2
Virginia, U of	6	57	5	10	33	20	2
Wabash C	8	13	—	—	—	—	—
Wagner C	3	8	—	—	—	—	—
Wake Forest U	5	15	2	0	—	—	—
Washburn U of Topeka	3	4	—	—	—	—	—
Washington C	6	1	—	—	—	—	—
Washington and Jefferson C	0	28	—	—	—	—	—
Washington and Lee U	0	13	—	—	—	—	—
Washington State U	10	6	6	6	24	6	1
Washington U	0	21	6	8	52	12	0
Washington, U of	52	21	9	21	74	14	2
Wayne State U	22	19	14	4	33	18	1
Waynesburg C	6	1	—	—	—	—	—
Weber State C	5	5	—	—	—	—	—
Wellesley C	2	12	—	—	—	—	—
Wesleyan U	1	16	3	2	—	—	—
West Chester State C	9	13	2	—	—	—	—
West Florida, U of	7	3	—	—	—	—	—
West Texas State U	0	9	1	—	—	—	—
West Virginia Institute of Tech	0	1	—	—	17	0	—
West Virginia State C	2	5	—	—	—	—	—
West Virginia U	10	42	1	3	47	8	1
Western Illinois U	9	6	0	—	—	—	—
Western Kentucky U	5	16	4	—	—	—	—
Western Maryland C	3	6	—	—	—	—	—
Western Michigan U	7	25	2	1	—	—	—
Western New England C	0	3	—	—	—	—	—
Western Washington U	5	10	0	—	—	—	—
Westminster C	1	2	—	—	—	—	—
Wheaton C (Illinois)	5	8	—	—	—	—	—
Wheaton C (Massachusetts)	1	4	—	—	—	—	—
Wheeling C	0	1	—	—	—	—	—
Whitman C	2	10	—	—	—	—	—
Whittier C	1	2	—	—	—	—	—
Wichita State U	6	1	4	1	—	—	—
Widener U	5	3	—	—	—	—	—
Wilkes C	14	5	—	—	—	—	—
Willamette U	3	8	—	—	—	—	—
William and Mary, C of	20	9	2	—	—	—	—
William Paterson C of New Jersey	0	7	—	—	—	—	—
Williams C	0	30	—	—	—	—	—
Wisconsin, U of							
Eau Claire	3	9	—	—	—	—	—
Green Bay	0	6	—	—	—	—	—
La Crosse	4	10	—	—	—	—	—
Madison	8	18	13	28	96	4	8
Milwaukee	9	13	12	2	—	—	—
Oshkosh	2	9	0	—	—	—	—
Parkside	5	6	—	—	—	—	—
Platteville	1	7	—	—	—	—	—
River Falls	10	9	—	—	—	—	—
Stevens Point	1	6	—	—	—	—	—
Superior	0	3	—	—	—	—	—
Wittenberg U	1	11	—	—	—	—	—
Wooster, C of	4	18	—	—	—	—	—
Worcester Polytechnic Institute	6	8	3	2	40	9	1
Wright State U	18	17	7	—	18	7	0
Wyoming, U of	3	0	1	1	18	7	0
Xavier U (Ohio)	6	14	4	—	—	—	—
Xavier U of Louisiana	4	13	—	—	—	—	—
Yale U	23	2	41	16	—	—	—
Youngstown State U	6	25	6	1	25	—	—
TOTALS	4337	6116	1609	1613	5831	1020	250

a Data not submitted. b Added in 1981. c Listed on basis of accreditation by AIChE-ABET. d The chemistry programs at Mount Saint Vincent College and Manhattan College are integrated into a combined department with all instruction in chemistry located at Manhattan College. e Master's degrees given by Atlanta University. **Note:** For brevity, "B.S." and "M.S." are used to denote all bachelor's and master's degrees, respectively, in each column.

Travel grants available for summer meetings

The Organometallic Subdivision of the ACS Division of Inorganic Chemistry expects to have available a limited number of travel grants for individuals planning to attend the 3rd International Symposium on Homogeneous Catalysis (ISHC) to be held in Milan, Italy, Aug. 30–Sept. 3. Funds for the grants will be given by the National Science Foundation and will be limited to advanced payment excursion fare from the point of departure to Milan.

In the event funds are granted, the subdivision would like to be able to inform successful applicants at the earliest possible time. If you are interested in being considered for a travel stipend, write to: ISHC Selection Committee, c/o J. E. Bercaw, Department of Chemistry, California Institute of Technology, Pasadena, Calif. 91125. Completed applications must be postmarked no later than May 1. Preference will be given to active investigators who intend to present significant new results; if you have made such plans please append a copy of your abstract to your application. Travel stipends from NSF require use of U.S. flag carriers.

The National Science Foundation has made available a limited number of travel grants to support individuals planning to attend the 4th International Conference on Organic Synthesis to be held in Tokyo, Japan, Aug. 22–27, 1982. Those interested in applying for international travel support should contact Prof. Conrad J. Kowalski, Department of Chemistry, University of Notre Dame, Notre Dame, Ind. 46556, Tel. (219) 239-5911. Completed applications must be received no later than May 14. Travel stipends are limited to the cost of airline tickets and require the use of U.S. flag carriers.

MAN AND MOLECULES

A SEA OF CHEMICALS

William Fenical
Scripps Institute of
Oceanography

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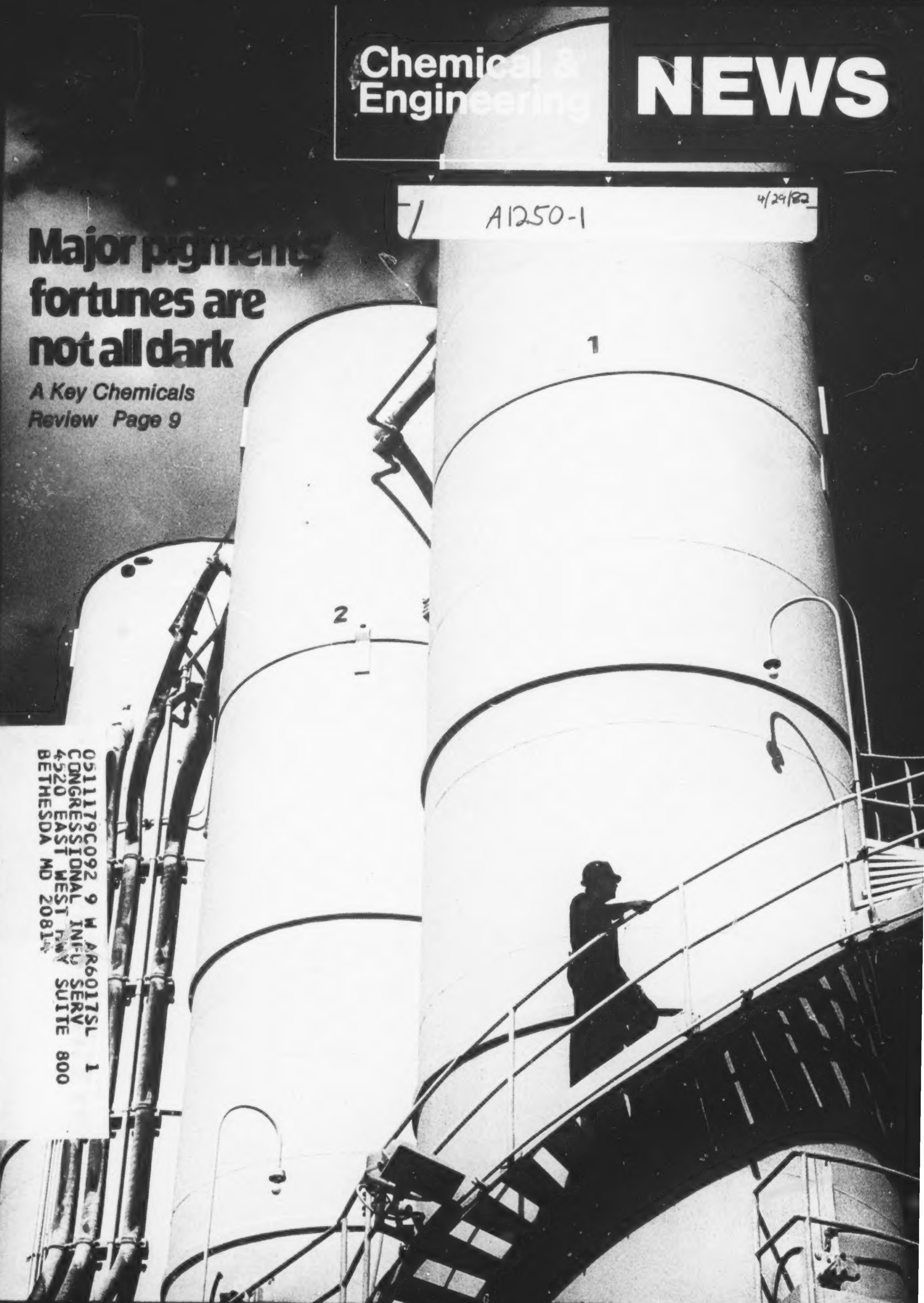
Chemical & Engineering NEWS

A1250-1

4/29/82

Major pigments' fortunes are not all dark

A Key Chemicals Review Page 9



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Chemical & Engineering NEWS

Cover: Kerr McGee Chemical's titanium dioxide facility at Hamilton, Miss.

2 Letters

Concentrates
8 Business
13 Government
16 Science/Technology

The Departments
27 ACS Comment
28 Meetings
36 Awards
48 Newscripts

News of the Week

- ***That the expected economic upturn did not occur*** *is reflected in first-quarter results; of 18 major chemical companies only one had an increase in earnings.* ***Page 4***
- ***Mineral supply*** *could be the crisis of the 1980s, Federation of Materials Societies tells Congressmen, citing lack of administrator for a minerals policy.* ***Page 5***
- ***Demand for chemical engineers*** *during the next five years probably will match the number of new graduates entering the marketplace, says AIChE.* ***Page 5***
- ***A laser pulse of 30 femtoseconds*** *achieved by Bell Labs scientists will enable them to study changes in semiconductor materials with greater precision.* ***Page 5***
- ***Most communities in the U.S. are unprepared*** *for a chemical disaster, such as a transportation accident, according to NSF-sponsored, four-year study.* ***Page 6***
- ***Unemployment among member chemists has risen*** *to 1.7% for men, 3.0% for women, data from annual survey by ACS's Office of Manpower Studies show.* ***Page 6***

Business

- ***Recession has hurt pigments,*** *as it has all chemicals tied to autos and housing; titanium dioxide's future is good but carbon black faces problems.* ***Page 9***

International

- ***Japan's petrochemical producers*** *had a poor 1981 and this year promises little better; dependence on imported naphtha for feedstock is the stumbling block.* ***Page 12***

Government

- ***U.S. companies that market chemicals in Europe*** *must meet a Dec. 31 deadline to add products to existing EEC inventory, a procedure that may prove costly.* ***Page 14***

Science

- ***Electric signals emitted from living cells*** *may be related to cellular reproduction and malignancy; electric pulses applied to cells can aid fusion.* ***Page 20***
- ***Biotechnology's ties to academia*** *given an upbeat analysis at recent San Francisco symposium.* ***Page 21***
- ***Photoelectrochemical semiconductor*** *developed at the University of Wisconsin, Madison, to study optical energy converted into electricity.* ***Page 23***

Technology

- ***Gas Research Institute boosts spending*** *for long-range gaseous fuels development up to $3 million, cites depletion of natural gas and drop in federal funding.* ***Page 26***

FIRST-QUARTER CHEMICAL EARNINGS TUMBLE

Chemical company executives must be wondering just how bad things can get. Every three months they hear that the turn in the recession is just around the corner, but that turn, like tomorrow, never seems to come.

Thus it seems for the quarter ending last month. The chemical industry was assured last summer that by now the economy would be picking up and the industry would have a spring full of balmy earnings. Instead, companies are being buffeted by results that will make earnings performance in 1981 seem rosy by comparison.

For 18 major basic chemical companies that have reported this year's first-quarter financial data so far, results have been abysmal. Combined sales for the 18 companies declined 6.1% to $17.0 billion from the first quarter last year. And combined earnings for the 18 companies plummeted 36.2% to $731 million.

These results are considerably worse than in the fourth quarter of 1981. The earnings drop in first-quarter 1982 was half again as great. Sales had risen a bit in the fourth quarter but fell this time. In all, the numbers bear out that the recession deepened considerably in first-quarter 1982, even if the rate of economic decline eased from the nosedive pitch of the fourth quarter.

Behind the bottom-line damage companies are now reporting physical business volume, measured by production indexes, was off about 12% this winter from a year ago. That's trouble all by itself but was magnified by price problems. Many basic chemicals and polymers were discounted up to a third or more from list prices. The pricing disaster was far greater than indicated by official government chemical price indexes, which try to reflect real-market discounts but never really catch up.

Combined with still-increasing energy costs, steadily rising wage costs, and sky-high financing costs, the woeful state of prices and production overcame all efforts at companies to tighten the belt and increase productivity. The result is the uniform profits gloom showing up in first-quarter reports.

Of the 18 companies that have reported, only four—Allied, Celanese, Chemed, and Stauffer Chemical—had increases in sales. And as far as earnings are concerned, thus far, tiny Chemed, spun off from W. R. Grace, shines brightly as the only company with an increase in earnings for the quarter. Chemed's earnings increased 4.2% from first-quarter 1981 to $5.2 million; its sales rose 2.0% to $59.9 million.

Two of the 18 companies reported losses for the first quarter. Akzona suffered a loss of $2.7 million compared to a profit of $3.3 million in the first quarter last year. Its sales declined 5.9% to about $291 million. And B. F. Goodrich had an $18.4 million loss, compared to earnings of $9.3 million in first-quarter 1981. The company's sales fell 6.6% to almost $729 million.

Apart from these two companies, the greatest earnings drop percentagewise for the quarter occurred at PPG Industries, where earnings fell 70.2% from the year-earlier period to $16.5 million. Its sales were down 7.1% to a little more than $752 million.

This is not the greatest sales drop among the 18 companies by far. That distinction is held by International Minerals, whose sales fell 21.6% to about $419 million. IMC's earnings dropped 44.0% to $23.5 million, which was just the seventh largest drop among the 18 companies.

Union Carbide had the second largest sales decline, 12.4%, to $2.31 billion. Its earnings drop of 49.0% to $90.8 million is the largest decline in terms of dollars among the 18 companies—down $87.2 million—from year-before levels.

As expected, the economy has been blamed for the declines at almost all of the companies. For instance, Monsanto chairman and chief executive officer John W. Hanley says, "Our first-quarter results reflect the continuing recessionary business environment around the world. The quarter opened with a continuation of the widespread industrywide inventory liquidation process that began in the latter part of 1981. Although our shipments levels improved somewhat as the quarter progressed, they were still below the year-ago levels. With tight inventory controls in place, our operating rates were some 13 percentage points below those experienced during the first quarter of 1981." □

Only Chemed had earnings increase in first quarter

$ Millions	First-quarter 1982 Sales	First-quarter 1982 Earnings[a]	Change from 1981 Sales	Change from 1981 Earnings	Profit margin[b] 1982	Profit margin[b] 1981
Akzona	$ 290.5	$−2.7	−5.9%	def	def	1.1%
Allied	1614.0	63.0	2.0	−25.0	3.9	5.3
American Cyanamid	845.5	38.0	−4.7	−20.8	4.5	5.4
Celanese	850.0	20.0	6.7	−44.4	2.4	4.0
Chemed	59.9	5.2	2.0	4.2	8.7	8.5
Diamond Shamrock	791.1	29.1	−9.3	−52.1	3.7	7.0
Dow Chemical	2781.0	97.0	−4.0	−46.1	3.5	6.2
Ethyl Corp.	402.7	17.1	−5.3	−19.3	4.2	5.0
B. F. Goodrich	728.6	−18.4	−6.6	def	def	1.2
W. R. Grace[c]	1463.2	79.1	−1.8	−5.3	5.4	5.6
Hercules[d]	640.0	21.9	−4.2	−41.8	3.4	5.6
International Minerals	419.2	23.5	−21.6	−44.0	5.6	7.9
Monsanto	1731.7	147.5	−8.9	−16.2	8.5	9.3
Pennwalt	246.7	5.3	−7.9	−45.9	2.1	3.7
PPG Industries[e]	752.2	16.5	−7.1	−70.2	2.2	6.8
Rohm & Haas[f]	475.3	16.0	−0.7	−41.6	3.4	6.6
Stauffer Chemical	630.3	82.1	0.2	−6.6	13.0	14.0
Union Carbide	2312.1	90.8	−12.4	49.0	3.9	6.7

a After-tax from continuing operations, excluding extraordinary and nonrecurring items. b Net earnings as a percentage of sales. c Excludes nonrecurring gain of $85.1 million in first-quarter 1982. d Excludes nonrecurring gain of $5.3 million, first-quarter 1981. e Excludes nonrecurring first-quarter 1982 gain of $7.6 million. f Excludes nonrecurring first-quarter 1981 gain of $7.6 million. def = deficit.

Recession dulls major pigments' luster

Despite the current downturn, titanium dioxide has makings for some good years ahead; further shakeout will have to come first for carbon black

Key Chemicals

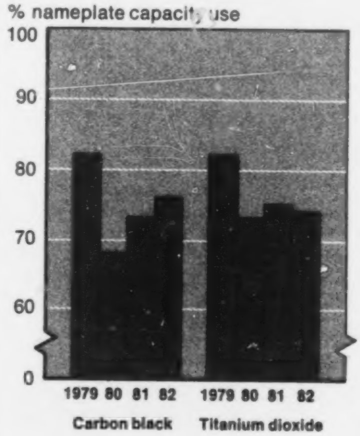
Fortunes for the two leading pigments are literally black and white. Although their strong tie to auto and housing markets has laid them both open to damage from the current recession, titanium dioxide and carbon black contrast sharply in their underlying health. The white pigment basically is stronger than most other large-volume U.S. chemicals and the black one is much weaker.

Despite the current downturn, titanium dioxide has several important advantages over most other chemicals. These pluses could lead the dominant white pigment into pretty good performance if the U.S. economy finally can shake off the stop-and-go recessionary pace of the past two years. Even now, titanium dioxide has fairly high effective plant capacity use, reasonably stable prices, much improved technology, readily available nonhydrocarbon feedstocks, a thriving foreign trade without too much threat from imports, and little real competition from other pigments.

The same can't be said for carbon black, one of the most woebegone chemicals of them all. Its only advantage is that it got to its present condition years ahead of other chemicals now facing similar problems of maturing markets and excessive investment. Carbon black producers saw their business top out way back in 1974. By 1979, they were ready to bite the bullet. By next winter, they will have shut down one quarter of total capacity in a massive shakeout. Brutal market pressure from customers in tires and autos has forced less efficient producers out of business and chopped prices roughly 20% in just the past year. It's the sort of bloodletting reminiscent of polyester fiber in the late 1970s, although it could lead similarly to brighter business prospects down the road.

But not in 1982 or 1983. Industry analysts view production of both carbon black and titanium dioxide this year down slightly from 1981 with total value unchanged at $1.8 billion. Next year, production might recover and expand slightly. But the net result will be a four-year pause in business for these chemicals.

One quarter of pigments' plant capacity is unused



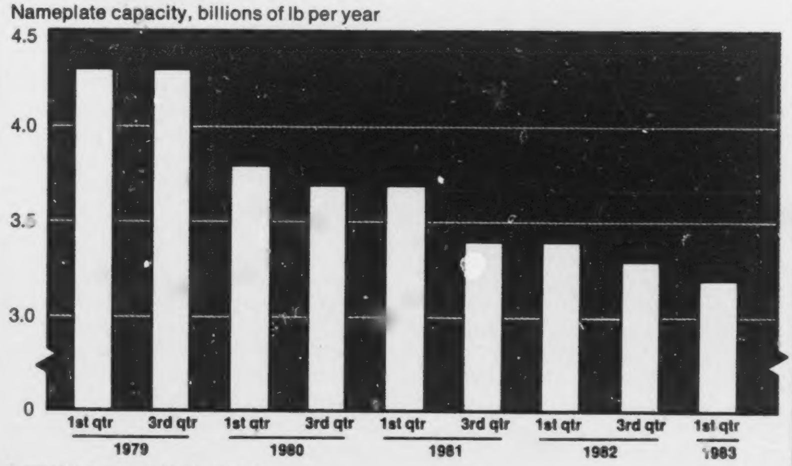
Sources: Commerce Department; industry and C&EN estimates

After 1983, the long-term outlook diverges for the two chemicals. Most analysts forecast steady market growth for titanium dioxide, perhaps 2% per year through the decade. For a few years, present U.S. capacity plus some imports could meet demand. But by 1985, U.S. capacity would be pushed to its practical limit of about 850,000 tons per year. Plant additions would have to be in the planning stages now to emerge full blown about mid-decade. As yet, there have been no announcements. Although a supply crunch sounds like a crackpot idea at the moment, it could materialize if a sustained recovery comes to the U.S. economy.

For carbon black, analysts forecast a slow average decline in demand through 1990 with the rate increasing until 1985 and then slowing down. Forces at work will be smaller, longer lasting tires, lighter cars, reduced mileage per car, and strong auto imports with imported tires. Thus, although foreign trade in carbon black itself is small, imports of tires made with foreign-produced carbon black could be an increasing problem. Effectively, U.S.-made carbon black could be losing market share.

Bruce Greek, Houston, and
William Fallwell, Washington

Carbon black capacity is one fourth less than in 1979



Sources: Industry and C&EN estimates

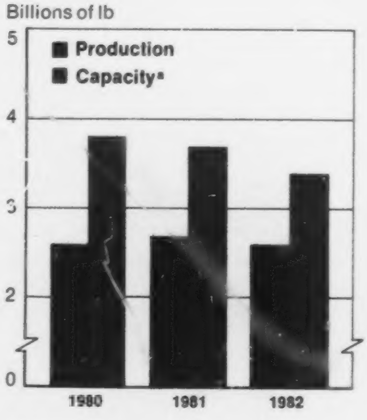
Key Chemicals

C

Carbon black

- ***Demand depressed***
- ***Plants shutting down***
- ***Prices woeful***

PRODUCTION/CAPACITY



[a] First quarter.

HOW MADE

Partial oxidation of carbon black oil (like fuel oil) from refineries

MAJOR END USES (U.S.)

Tires 65%, other rubber products 25%, colorant and filler for plastics, inks, and the like 10%

FOREIGN TRADE

Exports—declining to under 100 million lb, imports—holding at under 25 million lb

PRICES

List price 25 to 35 cents per lb with most at low end; discounting widespread

COMMERCIAL VALUE

$800 million for production, 1982

U.S. carbon black producers continue trying to get their act together under pretty disheartening conditions. In this shape-up campaign, companies have been shutting down obsolete plants, paring inventories, and holding production reasonably steady. But these actions haven't led yet to one critical improvement needed—picking profits off the floor.

Part of producers' problem is that too many customers know too much about their business. For example, the most important user group down the line, the big auto makers, knows that crude oil prices are declining along with prices of carbon black's feedstock, a heavy refinery fraction called carbon black oil. Detroit wants, and apparently gets, corresponding price cuts in tires. Then tire makers pass the price-cutting pressure back to carbon black. So carbon black prices are reeling, down roughly 20% over the past year. These prices cover quite a range but get as low as 25 cents per lb or less.

So carbon black's low profits will not go away at least until after this year. One sure sign is that producers continue to shut down plants. In 1981, more than 300 million lb per year of nameplate capacity was shut down permanently. Other capacity was closed "temporarily," leading to questions on whether it ever will be restarted. For 1982, more than 200 million lb of capacity might be shut down permanently.

Of course, candidate plants for shutdown become harder to find after a three-year capacity shakeout. The industry will be decidedly leaner after losing fully one quarter of its capacity from mid-1979 through the end of this year.

As 1982 opened, U.S. nameplate capacity for carbon black totaled about 3.4 billion lb, including a tiny amount for thermal-process carbon black. Furnace-process black accounts for all the rest.

Production in 1982 is expected to range from the 1981 level of 2.7 billion lb down to less than 2.5 billion lb for a 10% drop. If production splits the middle at 2.6 billion lb, plants will run at 76% of first-quarter capacity. This use rate would be higher than in 1981, when first-quarter capacity of 3.7 billion lb ran at 73% producing 2.7 billion lb. The actual operating rate rose during the year as capacity was shut down.

The outlook for 1982 depends heavily on a second-half recovery in U.S. auto production and tire sales. Current guesses are that carbon black production fell off 15% in the first quarter from first-quarter 1981. Industry analysts have noted a small pickup lately, but they predict that second-quarter production also will be lower than in 1981.

So analysts' predictions for 1982 obviously rest on a pickup later. Inventories will play a role. Carbon black inventories are considered minimal for the current level of tire production. Therefore, if tire production surges to fill second-half demand and replenish inventories, carbon black production also might pick up to fill the product pipeline. Such reasons underlie hopes that actual 1982 production of carbon black will about match that of 1981.

Rubber products other than tires account for a quarter of U.S. carbon black demand. Unfortunately, much of this "rubber mechanical goods" also goes to automotive uses. Hence, when auto and truck production weakens, most carbon black markets suffer.

The remaining segments of mechanical goods such as belting are tied closely to the general level of industrial production. When industrial production declines, associated materials-handling functions, which use belts, decline equally.

The smaller uses of carbon black in plastics, inks, paints, and elsewhere have little effect on total demand. The best growth rates will be no more than twice constant-dollar gross national product or 4% per year.

Hence, carbon black really depends on tires for the major shifts in its use—a prospect not very encouraging at the moment. Since tires now have smaller sizes and longer lives in a reduced U.S. auto business, use of U.S.-made carbon black might be flat or falling longer than producers would like to think.

The only consolation for producers is that they have acted decisively and early in this recessionary period to adjust capacity to the new market reality. Although painful, these moves will shorten the time needed for business to brighten again in any sustained general economic recovery.

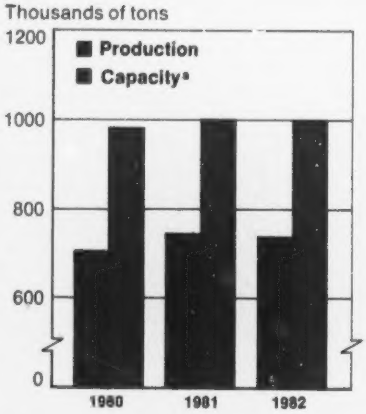
Key Chemicals

TiO_2

Titanium dioxide

- ***Production easing***
- ***Capacity flat***
- ***Prices a bit soft***

PRODUCTION/CAPACITY



[a] First quarter.

HOW MADE

Recovered from natural or synthetic ores using chlorine or sulfuric acid

MAJOR END USES

Hard-surface coatings 50%, paper coatings and fillers 25%, plastics and rubber fillers 15%, ceramics 5%

FOREIGN TRADE

Exports—expected up, to 70,000 tons in 1982; imports—also up, to 110,000 tons in 1982

PRICES

Anatase form 69 to 70 cents per lb; rutile form 75 cents per lb; modest discounting

COMMERCIAL VALUE

$950 million for production, 1982

U.S. titanium dioxide producers can't boast that they are immune to the present recession, since they have large markets in auto and house paint. But they can feel fortunate. In output, plant use, price, foreign trade, technology, and raw materials, titanium dioxide is faring far better than most other large-volume U.S. chemicals. If recovery ever arrives for the U.S. economy, the white pigment could be well off in a year or two.

However, for 1982, titanium dioxide faces stagnation after a better than expected 1981. This year, production likely will be down slightly. Plant capacity will be flat. And even with list prices up a bit from a year ago, profitability will be marginal.

Industry analysts familiar with this pigment think that 1982 production probably will total 740,000 tons, off slightly from just over 750,000 tons in 1981. Total U.S. use will be higher than production again because of imports and an inventory drawdown. Use this year is expected to be about 775,000 tons, down from about 790,000 tons in 1981.

Titanium dioxide plants' nameplate capacity comes to just over 1 million tons per year. Actual sustainable capacity is a controversial matter but is much less than nameplate. Estimates of effective capacity range from 820,000 to 880,000 tons, with opinion weighted toward the lower end of the range considering today's rough economic conditions.

Behind the relatively large downgrading for effective capacity are technical limits to production due largely to the switchover time necessary to make the variety of product grades. These grades have two basic crystal forms corresponding to the two basic raw materials, anatase and rutile. Although efforts are under way to develop finished forms that can be used in more diverse products, some forms always will be limited to certain final uses, especially in the dominant coatings market. Hence, effective capacity will continue to be a lower fraction of nameplate capacity than is the case for many other chemicals.

If the resulting effective capacity is 850,000 tons, the effective operating rate for 1981 would have been 88%. (Use of nameplate capacity was 75%.) If effective capacity is as low as 825,000 tons, the effective 1981 use rate would have been 91%, quite decently high.

This year the effective plant-use rate might be off a bit to 87%, assuming effective capacity holds at 850,000 tons. At an effective capacity of 825,000 tons, the plant-use rate still would be a healthy 90%.

But even with such respectable operating rates, no one in the industry has good profitability. Clear evidence is the dearth of announcements of new plants or expansions. Capital investment in a titanium dioxide plant is said by industry analysts to be one of the highest of all large-volume chemicals. So investment will "hesitate" for the pigment even when capacity use is high if current return on investment isn't very good.

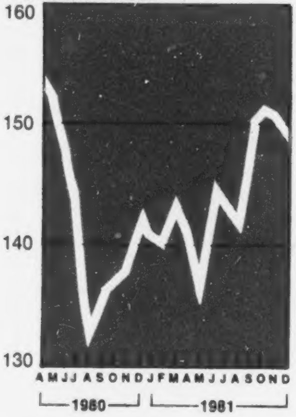
The basic problem for titanium dioxide producers is a common one—product maturity, which lays the pigment open to the ups and downs of general business cycles. This year is a good example. Total use of titanium dioxide will fall 2% this year because of the depressing influence of the gross national product.

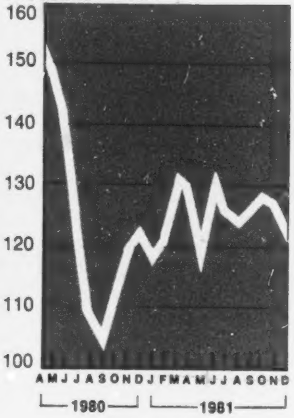
Paint, which accounts for just over half of titanium dioxide use, was off in volume in 1981 and will be off again in 1982. The decline of titanium dioxide content in trade sales (retail) paint apparently has about ended. But efforts to improve paint quality, including use of more titanium dioxide, haven't gotten off the ground. As a result, the dominant use of titanium dioxide will follow GNP with little new market penetration for at least another year.

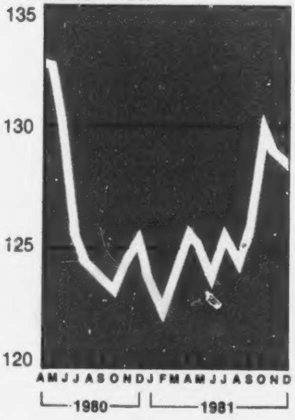
Use of titanium dioxide in paper and fabricated plastics accounts for most of the other half of total use. These uses had their ups and downs in 1981 and will have more in 1982. Net prospects for titanium dioxide for these uses in 1982 are about the same as in 1981, assuming the economy improves in the second half.

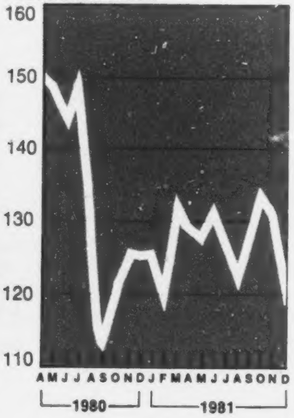
Unfortunately, a second-half upturn in the economy would come too late for paint because trade sales have their seasonal peak in the second quarter. Such unfortunate timing helps confirm that 1982 probably will be no better than a holding period for titanium dioxide.

Japanese chemical recovery still heavy going


All chemicals
Production index


Petrochemicals
Production index


Synthetic fibers
Production index


Synthetic rubber
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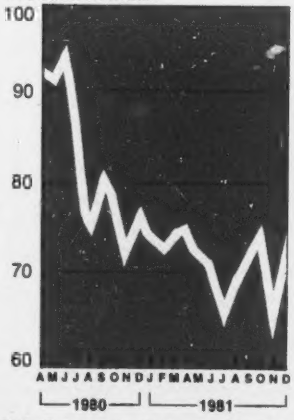
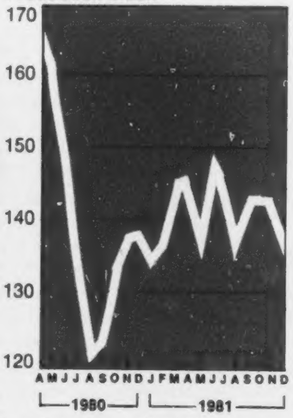

Fertilizer
Production index


Plastics
Production index

Note: Base year for all indexes, which are seasonally adjusted, is 1975 = 100.
Source: Ministry of International Trade & Industry

Among Japanese chemical executives, 1981 won't be remembered fondly as one of those banner years. More than likely, 1982 won't be, either. The Japanese chemical industry, particularly the all-important petrochemical segment, has been—and still is—in big trouble.

Realistically, it took Japanese petrochemical producers more than five years to recover from what they refer to as "the first oil shock" of 1973. After the industry started to rebound, output climbed slowly but steadily, reaching its peak in fourth-quarter 1979 and first-quarter 1980.

Then, all of the industry's troubles started coming together at the same time. Customers in Japan, burdened with excessive inventory purchased in anticipation of future price increases, stopped buying. Domestic demand dropped. Production followed suit. In fact, it plummeted in the second and third quarters of 1980.

Since then, Japanese petrochemical producers have spent the fourth quarter of 1980 and all of last year trying to recover lost ground. They have succeeded, but only partially. Output still is well below the heights that it enjoyed in late 1979 and early 1980. Now there are signs that even last year's modest recovery may be difficult to sustain, much less improve upon.

The reason, of course, is that the problems that have plagued the Japanese petrochemical industry over the past few years are still there. Its basic weakness is dependence on high-priced naphtha. The industry simply can't compete with petrochemical industries based on lower-cost light feedstocks.

As a result, Japanese petrochemical exports are feeling the pinch. The country has been—and still is—swamped with chemical imports. The ones that hurt most are ethylene derivatives, particularly from the U.S. and Canada. Meanwhile, with domestic demand nothing to rave about, production still is suffering.

Last year's ethylene production, for instance, was only 3.65 million metric tons, down 13% from 1980. That level also is the lowest it has been since 1975.

The Ministry of International Trade & Industry (MITI) estimated that first-quarter 1982 demand for ethylene would be 850,000 metric tons. Final figures for the quarter aren't in yet, but it's unlikely that demand exceeded MITI's forecast.

Indeed, ethylene output in January was only 289,400 metric tons. That's not very encouraging, because a monthly ethylene output below 300,000 metric tons means that producers are operating their plants below 60% of capacity.

The situation likely will improve over the remainder of the year, but not very much. Meanwhile, imports continue to pour into Japan and exports suffer.

To cope with these problems, which are taking huge bites out of company profits, the industry is taking some drastic steps. So-called "antirecession" cartels have been set up for several petrochemical products to adjust production levels. Joint selling companies, such as the one for polyvinyl chloride, are being considered. Antidumping charges have been filed against U.S. petrochemical exports. More important, the industry finally has won some long-sought concessions on naphtha imports and domestic naphtha prices.

Earl Anderson, New York

Chemical & Engineering NEWS

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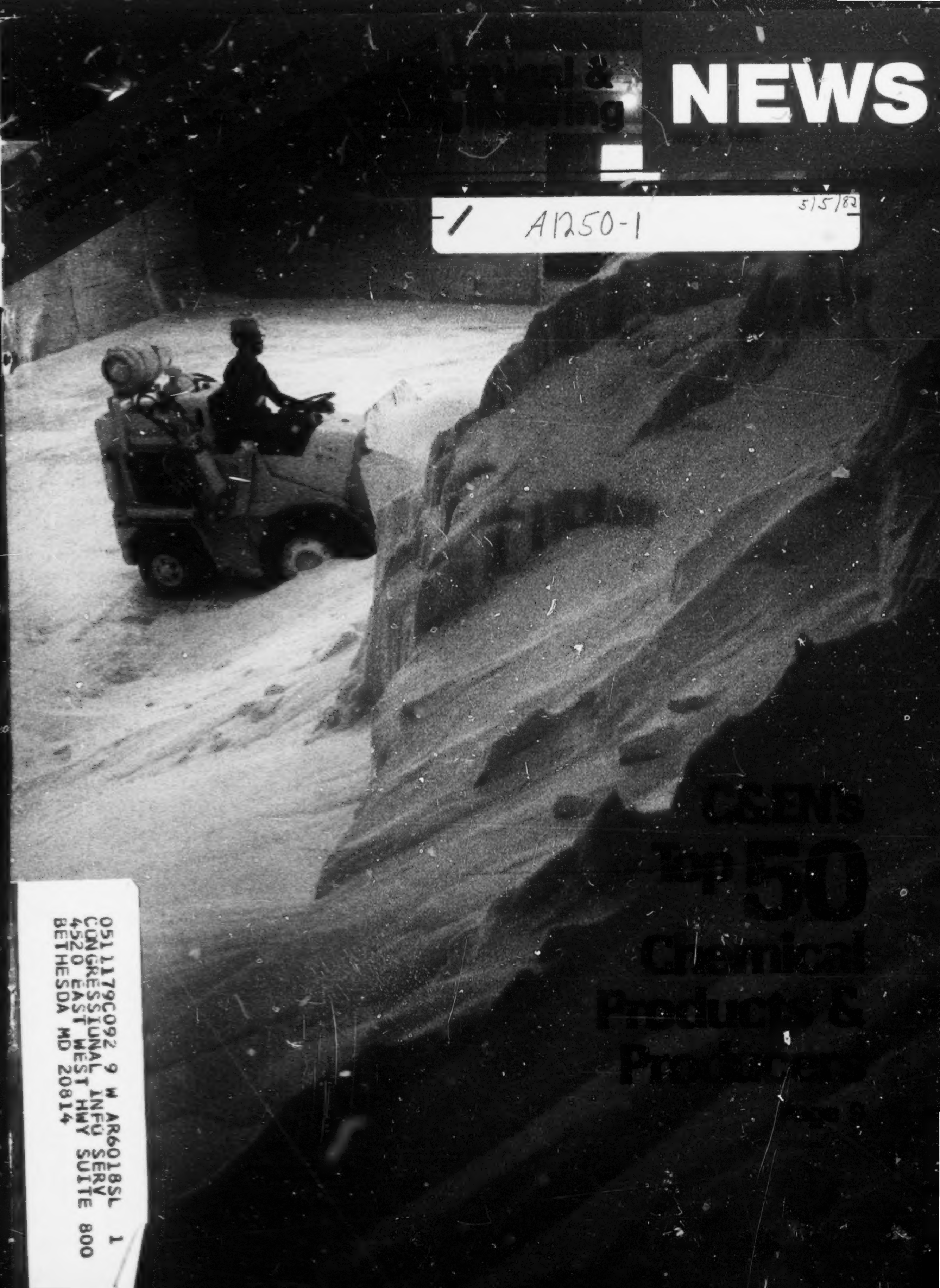

C&EN's Top 50 Chemical Products & Producers

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Chemical & Engineering NEWS

Cover: W. R. Grace's urea plant in Memphis

4 Letters

Concentrates
18 Business
25 Government
30 Science/Technology

The Departments
50 ACS Comment
51 Meetings
62 Newscripts

News of the Week

- ***Biological wastewater treatment systems*** *designed to meet EPA requirements control most toxic pollutants, CMA says.* ***Page 6***
- ***Modified tRNA gene*** *suppresses gene defect that causes blood disease.* ***Page 6***
- ***Detection of the magnetic monopole*** *claimed by Stanford scientists.* ***Page 7***
- ***National Academy of Sciences*** *adopts resolution calling on U.S., U.S.S.R. to reduce nuclear stockpiles.* ***Page 7***
- ***OTA report on nuclear waste disposal*** *calls for comprehensive federal policy through a new government agency.* ***Page 8***
- ***CIA report lists losses*** *of sensitive western technology to the U.S.S.R. and other eastern bloc countries.* ***Page 8***

News Focus

- ***C&EN's annual survey of 50 chemical products and producers*** *reveals declining production and low profits.* ***Page 9***

Business

- ***Experts see technological innovation policy*** *as too complex for mechanical analysis, suggest behavioral approach.* ***Page 23***

International

- ***World plastics producers*** *anticipate increased capacity by mid-1980s.* ***Page 24***

Government

- ***The fracas over the budget*** *still occupies Congress' attention but amendments to the clean air and drinking water acts are not being slighted.* ***Page 26***
- ***EPA holds hearings on lead-in-gasoline*** *regulations prompted by Vice Presidential task force recommendations.* ***Page 28***

Science

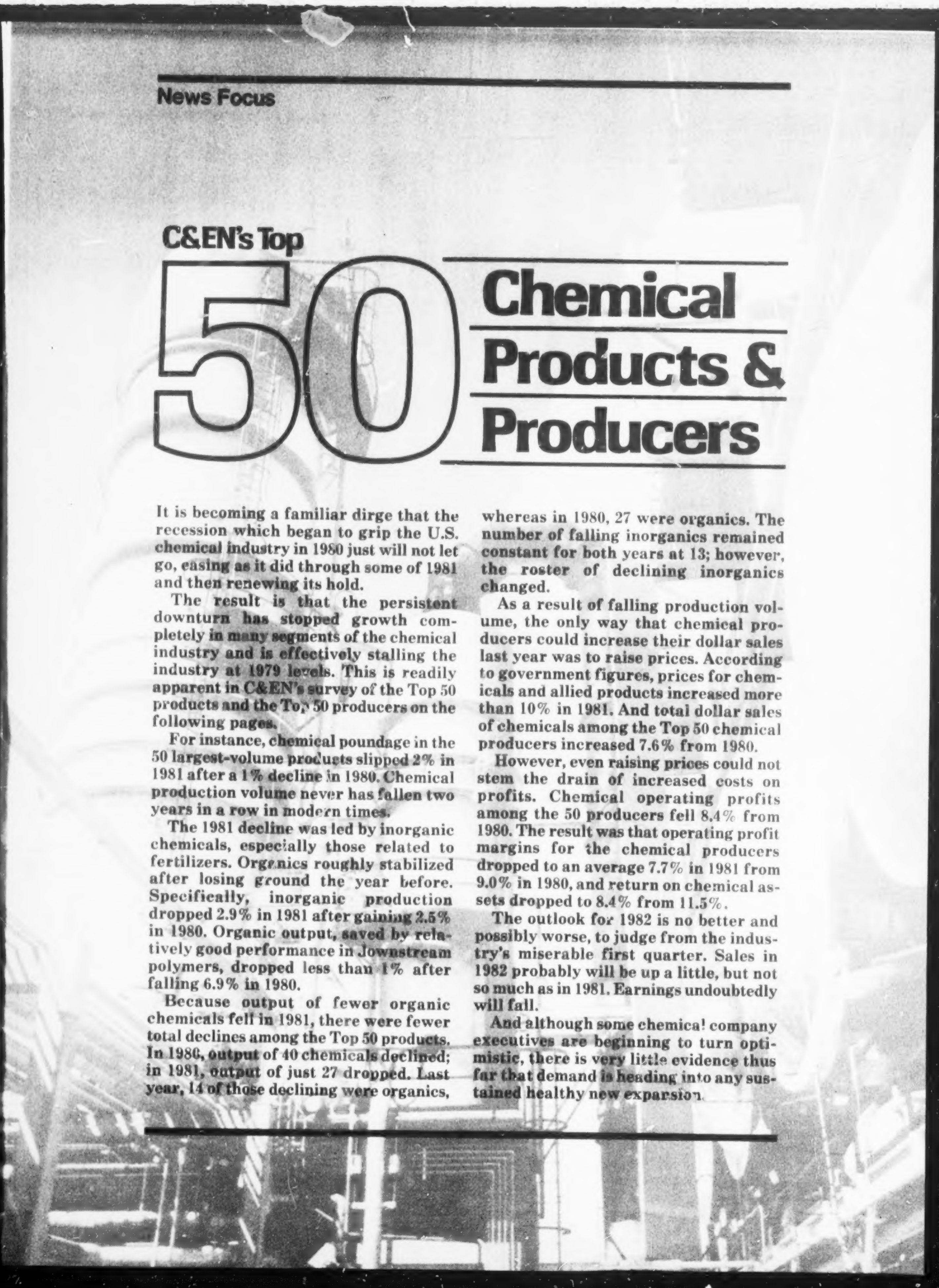
- ***Research on synthetic blood*** *from perfluorocarbon emulsions in U.S. and Japan shows promise.* ***Page 31***
- ***Tatyana Lozansky,*** *Soviet chemist and ACS member, plans hunger strike to force authorities to allow her to emigrate.* ***Page 34***

Education

- ***University of Rochester*** *chemical engineering sophomores use microcomputers to analyze data and control processes, reducing teaching load on a small faculty.* ***Page 37***
- ***New undergraduate chemistry laboratory*** *at California Institute of Technology contains modern, research-level instrumentation in unique design.* ***Page 39***

Books

- ***"Who's Poisoning America?,"*** *edited by Ralph Nader and associates, says corporate polluters should be held accountable for their actions.* ***Page 47***



C&EN's Top 50 Chemical Products & Producers

It is becoming a familiar dirge that the recession which began to grip the U.S. chemical industry in 1980 just will not let go, easing as it did through some of 1981 and then renewing its hold.

The result is that the persistent downturn has stopped growth completely in many segments of the chemical industry and is effectively stalling the industry at 1979 levels. This is readily apparent in C&EN's survey of the Top 50 products and the Top 50 producers on the following pages.

For instance, chemical poundage in the 50 largest-volume products slipped 2% in 1981 after a 1% decline in 1980. Chemical production volume never has fallen two years in a row in modern times.

The 1981 decline was led by inorganic chemicals, especially those related to fertilizers. Organics roughly stabilized after losing ground the year before. Specifically, inorganic production dropped 2.9% in 1981 after gaining 2.5% in 1980. Organic output, saved by relatively good performance in downstream polymers, dropped less than 1% after falling 6.9% in 1980.

Because output of fewer organic chemicals fell in 1981, there were fewer total declines among the Top 50 products. In 1980, output of 40 chemicals declined; in 1981, output of just 27 dropped. Last year, 14 of those declining were organics, whereas in 1980, 27 were organics. The number of falling inorganics remained constant for both years at 13; however, the roster of declining inorganics changed.

As a result of falling production volume, the only way that chemical producers could increase their dollar sales last year was to raise prices. According to government figures, prices for chemicals and allied products increased more than 10% in 1981. And total dollar sales of chemicals among the Top 50 chemical producers increased 7.6% from 1980.

However, even raising prices could not stem the drain of increased costs on profits. Chemical operating profits among the 50 producers fell 8.4% from 1980. The result was that operating profit margins for the chemical producers dropped to an average 7.7% in 1981 from 9.0% in 1980, and return on chemical assets dropped to 8.4% from 11.5%.

The outlook for 1982 is no better and possibly worse, to judge from the industry's miserable first quarter. Sales in 1982 probably will be up a little, but not so much as in 1981. Earnings undoubtedly will fall.

And although some chemical company executives are beginning to turn optimistic, there is very little evidence thus far that demand is heading into any sustained healthy new expansion.

Big-volume chemicals' output fell again in '81

Patricia L. Layman
C&EN, New York

C&EN's Top
50 Chemical Products

Last year showed what can happen, even in a traditional growth industry like chemicals, if recessions come too often or last too long. Not long after U.S. chemical producers breathed a sigh of relief that they had not been hit too hard in the 1980 recession, an even worse downturn hit toward the end of 1981.

From a big-product point of view, the main effect of the new recession was to spread the damage from organics, already suffering from 1980, to the inorganics. The result in 1981 statistics is that organics remained about where they were while inorganics dropped hard.

For C&EN's Top 50 chemical products, overall production in 1981 fell another 2% after a 1% dip in 1980. These percentages may seem small, but their meaning is momentous. The modern U.S. chemical industry never before has had back-to-back years of falling production. In fact, the industry's management always has been predicated on growth. The sustained pause in physical volume since 1979 has thrown previous strategy out the window.

In the specific product-by-product performance charted in the Top 50, proliferating minus signs for chemicals' 1980 production gave a combined 0.6% loss from 1979. This happened mainly because inorganics, which accounted for 68% of the total, were able to ride out the year with a 2.5% increase in production.

But 1981 caught up with inorganics. Their output slipped 2.9%, dragging the Top 50 as a whole down 2.2%, from about 560 billion lb (revised estimate) in 1980 to almost 548 billion lb in 1981. Organics production also slipped in 1981 but by much less than the year before, less than 1%, to about 175 billion lb.

For the Top 50 as a whole, drops in 1981 production were fewer, and, in general, less severe than in 1980. And the pattern of declines shifted. In 1980, 40 chemicals' output dropped, 27 of them organics. The 1981 declines, however, hit only 27 chemicals, but 13 were inorganic and 14 organic. In fact, organics led in output increases in 1981.

Most of the big (more than 10%) 1981 boosts in production blessed organics—urea, methanol, and toluene. The other major increase was in calcium chloride. In 1980, only two chemicals, nitrogen and ammonium nitrate, showed more than 10% growth over the year before.

Bad health in specific end uses cast a pall on several chemicals. For ex-

About the Top 50 list of chemical products

Government data, trade association figures, industry estimates. All of these go into preparing C&EN's annual list of the Top 50 chemical products, ranked by production volume. The federal government is relied upon most heavily, but when government figures are not available, other sources, primarily trade associations, are used. Industry sources and C&EN estimates are used only when other data are lacking or incomplete.

Government data are not always accurate—they are only as good as the information that individual companies report. But they are an objective measure of production extending back for many years. Therefore, relatively accurate indications of growth can be made on a consistent basis.

At this time of year, C&EN has access only to preliminary reports of production for 1981. When the government and trade associations issue their final reports, the outcome can be changed, sometimes dramatically. As a result, production figures for 1980 that appear in the table on page 11 may be different from those published at this time last year. The final reports also can affect the rankings of chemicals. The 1980 rankings of 29 of the chemicals listed in the table, for example, are different from those in the similar table published by C&EN a year ago.

The list itself covers production figures for the U.S., and includes chemicals produced for export. Candidates for the list include all basic, intermediate, chemically homogeneous finished products. These range from chemical building blocks such as ethylene and propylene to finished products such as vinyl acetate and ethylene glycol.

The roster also includes basic inorganic chemicals, but does not include what C&EN considers to be minerals, such as salt, potash, gypsum, and sulfur. Lime is included because it is processed and has many chemical and industrial applications. Refractory (dead-burned) dolomite is excluded in the calculations of lime production.

In the organics, such petrochemical feedstocks as ethane, butane, and propane are excluded arbitrarily, because they are considered to be products of oil companies and because they have many nonchemical uses.

There are other gray areas besides lime and petrochemical feedstocks. For example, the basic aromatics—benzene, toluene, and xylene—are included. Admittedly, this makes the list less pure chemically. Mixed xylenes and the para isomer are on the list. If production volume had warranted, the ortho isomer also would have been included.

Production figures are published by the government and trade associations in a variety of units—millions of pounds, thousands of tons, billions of cubic feet, millions of gallons, metric tons. To provide an accurate ranking and to make comparison of production volumes easier, C&EN not only gives production in common units but converts production to billions of pounds.

The Top 50 list, in addition to listing production figures for the past two years, indicates growth rates for the past year, the previous year, the past five years, and the past 10 years, giving the reader a historical perspective on growth for each chemical.

Inorganic chemicals' drop led Top 50 to 2.2% production decline in 1981

Rank			Production				Average annual change			
			Billions of lb		Common units[b]					
1981	1980[a]		1981	1980	1981	1980	1980–81	1979–80	1976–81	1971–81
1	1	**Sulfuric acid**	81.35	88.54	40,674 tt	44,272 tt	−8.1%	5.4%	3.1%	3.4%
2	2	**Ammonia**	38.07	38.09	19,037 tt	19,044 tt	−0.1	5.1	2.6	2.7
3	5	**Nitrogen**	37.31	34.71	485 bcf	479 bcf	1.3	16.0	11.0	11.2
4	4	**Lime**[c]	35.99	35.36	17,969 tt	17,680 tt	1.6	−8.8	−1.2	−0.4
5	3	**Oxygen**	34.93	35.68	422 bcf	431 bcf	−2.1	0.9	1.7	2.9
6	6	**Ethylene**	28.87	28.67	28,867 mp	28,667 mp	0.7	−4.1	5.6	4.6
7	7	**Sodium hydroxide**	21.30	23.25	10,649 tt	11,625 tt	−8.4	−6.2	0.3	1.0
8	8	**Chlorine**	21.12	22.84	10,559 tt	11,421 tt	−7.5	−5.7	0.3	1.2
9	9	**Phosphoric acid**	19.83	21.88	9,914 tt	10,938 tt	−9.3	7.9	4.5	5.2
10	11	**Nitric acid**	18.08	17.47	9,040 tt	8,733 tt	3.5	2.0	3.0	1.7
11	10	**Ammonium nitrate**[d]	17.58	18.25	8,791 tt	9,127 tt	−3.7	17.0	4.1	2.8
12	12	**Sodium carbonate**[e]	16.56	16.55	8,281 tt	8,275 tt	0.1	0.3	1.8	1.5
13	15	**Urea**[f]	14.97	12.96	14,970 mp	12,960 mp	15.5	−8.7	8.9	8.1
14	14	**Propylene**	14.02	13.68	14,016 mp	13,676 mp	2.5	−3.7	7.5	7.4
15	19	**Toluene**[g]	10.32	7.37	1,424 mg	1,017 mg	40.0	−38.0	4.6	5.0
16	13	**Benzene**	9.91	14.75	1,348 mg	2,007 mg	−33.0	20.0	−1.4	2.3
17	16	**Ethylene dichloride**	9.17	11.11	9,171 mp	11,108 mp	−17.4	−5.9	3.0	2.0
18	20	**Methanol**	8.41	7.15	8,408 mp	7,153 mp	17.8	−2.9	6.1	5.5
19	18	**Carbon dioxide**[h]	7.96	7.44	3,982 tt	3,720 tt	7.0	5.3	14.1	11.5
20	17	**Ethylbenzene**	7.85	7.64	7,847 mp	7,642 mp	2.7	−10.0	5.1	4.7
21	23	**Vinyl chloride**	6.72	6.47	6,720 mp	6,466 mp	3.9	1.2	3.2	4.5
22	21	**Styrene**	6.61	6.86	6,612 mp	6,856 mp	−3.6	−8.4	1.0	3.5
23	22	**Xylene**	6.43	6.59	887 mg	909 mg	−2.5	−4.3	−2.6	3.8
24	24	**Terephthalic acid**[i]	6.35	6.05	6,350 mp	6,054 mp	4.9	−1.7	4.7	10.6
25	26	**Formaldehyde**[j]	5.86	5.56	5,855 mp	5,555 mp	5.4	−6.9	0.8	2.6
26	27	**Ethylene oxide**	5.11	5.22	5,109 mp	5,220 mp	−2.1	−7.9	2.1	3.6
27	25	**Hydrochloric acid**	4.89	5.79	2,443 tt	2,895 tt	−15.6	−2.2	−0.6	1.5
28	29	**Ammonium sulfate**	4.22	4.27	2,111 tt	2,136 tt	−1.2	8.4	0.5	1.5
29	28	**Ethylene glycol**	4.06	4.39	4,055 mp	4,386 mp	−7.5	−7.3	3.8	2.8
30	30	***p*-Xylene**	3.70	4.24	3,696 mp	4,238 mp	−12.8	−8.9	2.9	8.3
31	31	**Cumene**	3.31	3.46	3,306 mp	3,459 mp	−4.4	−11.7	4.2	4.4
32	33	**Butadiene**[k]	3.05	2.80	3,046 mp	2,799 mp	8.8	−21.9	−2.9	−0.7
33	36	**Carbon black**	2.73	2.55	2,730 mp	2,546 mp	7.2	−24.0	−2.0	−1.0
34	32	**Acetic acid**	2.71	2.98	2,706 mp	2,977 mp	−9.1	−8.8	2.2	3.3
35	35	**Phenol**[l]	2.55	2.57	2,551 mp	2,568 mp	−0.7	−13.9	3.1	3.9
36	34	**Aluminum sulfate**	2.41	2.57	1,206 tt	1,286 tt	−6.2	4.4	0.3	0.7
37	37	**Sodium sulfate**[m]	2.33	2.28	1,164 tt	1,139 tt	2.2	−2.9	−1.1	−1.5
38	38	**Acetone**	2.17	2.08	2,167 mp	2,076 mp	4.4	−21.7	2.3	3.5
39	42	**Acrylonitrile**	2.01	1.83	2,006 mp	1,830 mp	9.6	−9.3	5.8	7.4
40	40	**Vinyl acetate**	1.93	1.92	1,934 mp	1,922 mp	0.6	−3.0	5.5	7.6
41	44	**Calcium chloride**[n]	1.83	1.62	917 tt	811 tt	13.1	−17.3	0.5	−2.8
42	43	**Propylene oxide**	1.81	1.77	1,810 mp	1,767 mp	2.4	−21.4	0.8	4.3
43	39	**Cyclohexane**	1.75	1.96	1,749 mp	1,964 mp	−10.9	−19.0	−4.3	0.1
44	41	**Isopropyl alcohol**	1.64	1.84	1,644 mp	1,836 mp	−10.5	−3.4	−0.9	−0.4
45	46	**Titanium dioxide**	1.50	1.57	750 tt	787 tt	−4.7	6.2	1.0	1.0
46	47	**Sodium silicate**	1.48	1.57	738 tt	785 tt	−6.0	1.0	−0.3	1.5
47	45	**Sodium tripolyphosphate**	1.37	1.58	687 tt	789 tt	−12.9	4.4	−1.1	−4.0
48	48	**Acetic anhydride**	1.25	1.47	1,248 mp	1,468 mp	−15.0	−2.5	−3.7	−1.9
49	50	**Adipic acid**	1.21	1.20	1,210 mp	1,200 mp	0.8	−33.3	−4.4	−0.8
50	49	**Ethanol**[l]	1.16	1.45	1,157 mp	1,451 mp	−20.3	3.1	−0.4	−3.4
		TOTAL ORGANICS IN TOP 50	**174.91**	**176.04**			**−0.6%**	**−6.9%**	**3.8%**	**4.5%**
		TOTAL INORGANICS IN TOP 50	**372.84**	**383.86**			**−2.9%**	**2.5%**	**2.8%**	**2.8%**
		GRAND TOTAL OF TOP 50	**547.75**	**559.90**			**−2.2%**	**−0.6%**	**1.6%**	**3.4%**

a Revised. **b** tt = thousands of tons, bcf = billions of cubic feet, mp = millions of pounds, mg = millions of gallons. **c** Except refractory dolomite. **d** Original solution. **e** Synthetic and natural. **f** Primary solution. **g** All grades. **h** All forms. **i** Includes both acid and ester without double counting. **j** 37% by weight. **k** Rubber grade. **l** Synthetic only. **m** High and low purity. **n** Solid and liquid.
Sources: Bureau of the Census, Bureau of Mines, International Trade Commission, C&EN estimates

Polymer recovery in 1981 was led by synthetic fibers

Production	Billions of lb		Common units					Average annual growth			
	1981	1980	1981	1980	1979	1976	1971	1980-81	1979-80	1976-81	1971-81
PLASTICS (millions of lb)											
Thermosetting resins	**4.18**	**4.52**	**4,174**	**4,517**	**4,856**	**3,633**	**2,897**	**−7.6%**	**−7.0%**	**2.8%**	**3.7%**
Phenolic and other tar acid resins	1.49	1.75	1,489	1,745	1,781	1,340	1,194	−14.7	−2.0	2.2	2.2
Urea resins	1.17	1.31	1,167	1,311	1,367	821	636	−11.0	−4.1	7.3	4.8
Polyesters (unsaturated)	1.00	0.95	996	952	1,147	1,042	730	4.6	−17.0	−0.9	3.2
Epoxies (unmodified)	0.34	0.32	341	323	361	244	169	5.6	−10.5	6.9	7.2
Melamine resins	0.18	0.19	181	186	200	186	168	−2.7	−9.5	−0.5	0.7
Thermoplastic resins	**27.30**	**26.45**	**27,296**	**26,444**	**28,083**	**20,582**	**14,093**	**3.2%**	**−5.8%**	**5.8%**	**6.2%**
Low-density polyethylene	7.05	7.19	7,045	7,189	7,793	5,813	4,458	−2.0	−7.8	3.9	4.7
Polystyrene and copolymers	5.69	5.54	5,687	5,540	5,320	4,296	3,748	2.7	4.1	5.8	4.2
Polyvinyl chloride and copolymers	5.66	5.49	5,663	5,485	6,119	4,716	3,471	3.2	−10.4	3.8	5.0
High-density polyethylene	4.95	4.53	4,953	4,531	5,010	3,125	1,928	9.3	−9.6	9.7	9.8
Polypropylene and copolymers	3.95	3.70	3,948	3,699	3,841	2,632	1,288	6.7	−3.7	8.5	11.8
TOTAL[a]	**31.48**	**30.97**	**31,470**	**30,961**	**32,939**	**24,215**	**17,790**	**1.6%**	**−6.0%**	**5.3%**	**5.9%**
SYNTHETIC FIBERS (millions of lb)											
Cellulosics	**0.77**	**0.81**	**771**	**806**	**930**	**751**	**1,391**	**−4.3%**	**−13.3%**	**0.5%**	**−11.2%**
Rayon	0.51	0.49	510	490	606	453	915	4.1	−19.1	2.4	−5.7
Acetate	0.26	0.32	261	316	324	298	476	−17.4	−2.5	−6.2	−5.8
Noncellulosics	**9.03**	**8.73**	**9,026**	**8,741**	**9,433**	**7,291**	**4,761**	**3.3%**	**−7.3%**	**4.4%**	**6.6%**
Polyester	4.18	3.99	4,176	3,989	4,178	3,341	1,831	4.7	−4.5	4.6	8.7
Nylon[b]	2.33	2.36	2,333	2,358	2,721	2,076	1,595	−1.3	−13.3	2.3	3.9
Glass fiber	1.04	0.87	1,041	867	1,014	676	468	20.1	−14.5	8.9	8.4
Olefin	0.79	0.75	785	748	759	577	322	4.9	−1.5	6.3	9.3
Acrylic[c]	0.69	0.78	691	779	761	621	545	−11.3	2.4	2.2	2.4
TOTAL[a]	**9.80**	**9.54**	**9,797**	**9,547**	**10,363**	**8,042**	**6,152**	**2.6%**	**−7.9%**	**4.0%**	**4.7%**
SYNTHETIC RUBBER (thousands of metric tons)											
Styrene-butadiene[d]	2.27	2.37	1,032	1,074	1,378	1,333	1,416	−3.9	−22.1	−4.9	−3.1
Polybutadiene	0.75	0.69	342	311	397	352	254	9.9	−21.7	−0.6	3.0
Ethylene-propylene	0.39	0.32	178	144	175	130	60	23.6	−17.7	6.4	11.5
Butyl	0.37	0.37	168	168	194	125	106	nc	−13.4	6.1	4.7
Neoprene	0.32	0.33	143	151	183	165	e	−5.3	−17.5	−2.8	e
Nitrile	0.17	0.15	75	70	75	73	65	7.1	−6.7	0.5	1.4
Polyisoprene	0.11	0.11	52	50	69	74	117	4.0	−27.5	−6.8	−7.8
Other[f]	0.09	0.11	40	50	66	51	222	−20.0	−24.2	−4.7	e
TOTAL[a]	**4.47**	**4.45**	**2,030**	**2,018**	**2,537**	**2,303**	**2,240**	**0.6%**	**−20.5%**	**−1.6%**	**−0.5%**

a Totals are for those products listed. Totals may not add because of rounding. b Includes aramid. c Includes modacrylic. d Excludes high-styrene latex. e Data for neoprene and "other" are combined for 1971. f Includes chlorosulfonated polyethylene, polyisobutylene, and acrylic, fluoro, polysulfide, and silicone elastomers. nc = no change. **Sources:** Society of the Plastics Industry, Textile Economics Bureau, Rubber Manufacturers Association

ample, production of ammonium nitrate, ammonia, and phosphoric acid—all tied to fertilizer, which took a turn for the worse last year after a healthy 1980—fell last year, although urea output continued strong. In 1980, all four chemicals had shown strong growth as fertilizer use boomed both in the U.S. and in exports.

If 1981 production figures are compared with initial 1980 data in last year's Top 50 (C&EN, May 4, 1981, page 35), the chemical output picture changes, but only superficially. Total 1981 production, for example, would have been up 0.9%, with organics up 0.8% and inorganics up 0.9%. However, initial government data are not always accurate and usually lead to revisions.

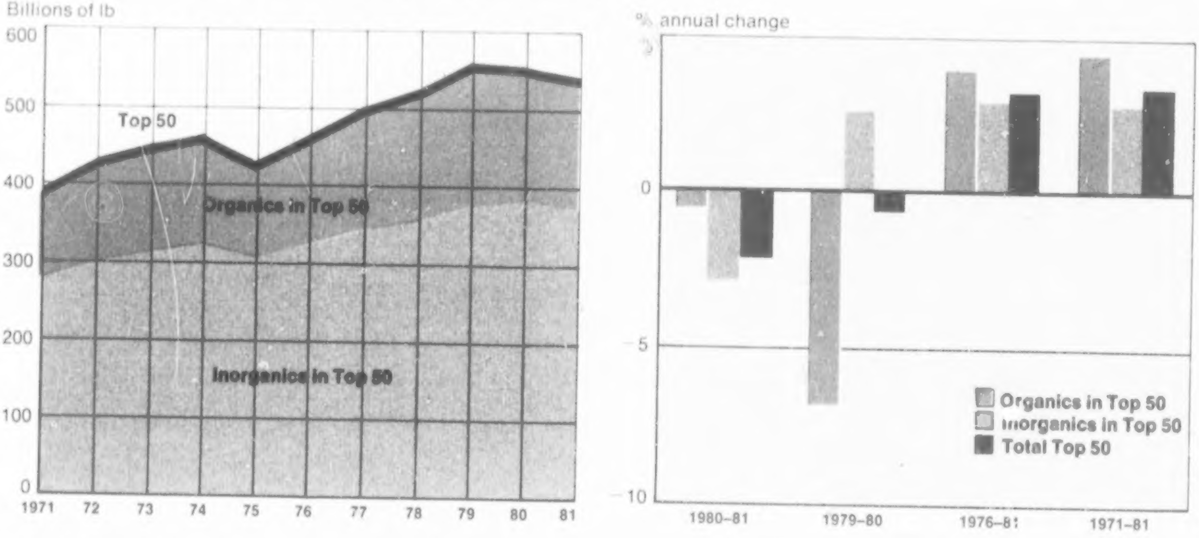
Indeed, some people enjoy taking potshots at government data. But agencies reply that they report only the information that individual companies supply them. The upshot is that revisions and other changes are probably an inherent part of the system, for monthly reports in particular.

Unfortunately, some bureaucrats contend that the quality of data being submitted is declining. This is far more troublesome than mere tardiness. Some agency officials say that many companies are giving the responsibility of government reporting to increasingly inexperienced nontechnical people who don't know the difference between forms, let alone between chemicals.

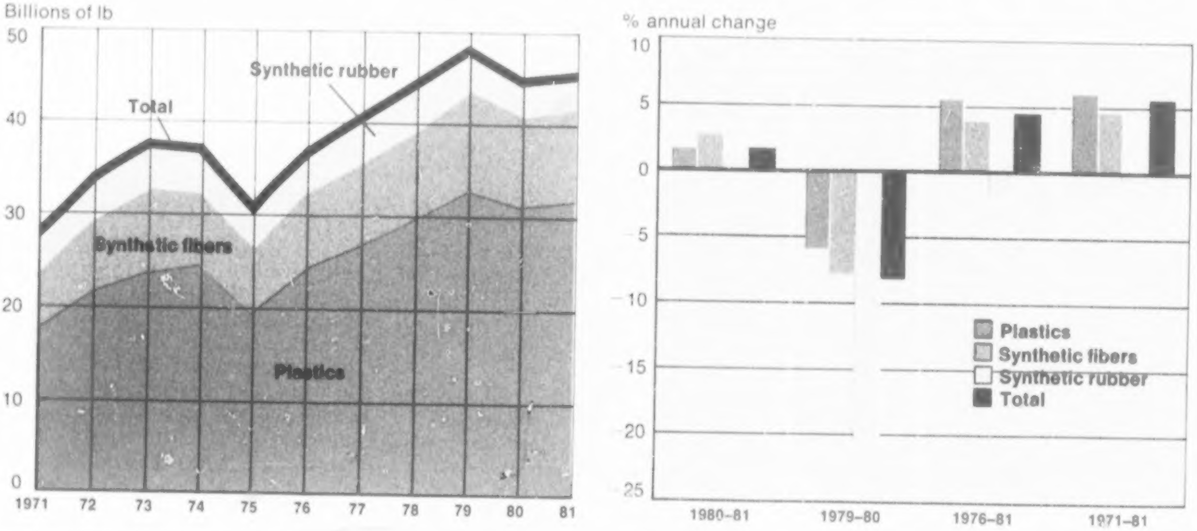
The result? Data are entered on wrong lines on the forms, entered with incorrect units, or not entered at all. Government officials can tick off cases of a company market researcher calling to protest the published data on a particular product, only to learn with chagrin that it was the same company's government reporting unit that supplied incorrect data.

All this can lead to sizable errors in

Production of basic chemicals fell again in 1981...



...although polymers made a slight recovery from a bad 1980



reporting, which subsequently must be corrected in revisions. Sometimes, the revisions can be drastic. For example, 1980 preliminary data for benzene showed production of about 1.50 billion gal, but it was later revised to 2.01 billion gal. Preliminary production for toluene was given as 1.56 billion gal, but revised to 1.02 billion gal. By contrast, production of cyclohexane was pegged at 1.97 billion lb in preliminary reporting and at 1.96 billion lb in the revised data.

For polymers, the 1980 and 1981 data picture is clearer. Interestingly, data here are not handled by the government but by industry associations. Although collection of polymer statistics is more efficient and accurate than are the government data, industry sources are quick to point out that polymer categories are far fewer, with fewer producers to keep track of.

Even with revised figures, 1981 production and consumption for plastics and synthetic fibers clearly picked up, and the beleaguered synthetic rubber industry reported modest growth.

Synthetic fibers did best. A rebound in noncellulosic-fibers production pulled up the overall category 2.6% in 1981. Cellulosics, however, still showed a 4.3% decline in output, although that was an improvement from the 13.3% loss in 1980.

Similarly, a 1981 upturn in thermoplastic resins output of 3.2% lifted the entire plastics category 1.6%, even though the smaller segment of thermoset resins declined 7.6% from 1980 production.

Synthetic rubber production rose 0.6% in 1981, spurred primarily by a 23.6% boost in production of ethylenepropylene-diene monomer. Weakness still showed, however, with styrene-butadiene and neoprene. And butyl rubber showed no change from 1980 production. □

Top chemical companies had a rough year

William J. Storck
C&EN, New York

C&EN's Top
50 Chemical Producers

In many ways, 1981 was a year that, financially speaking, U.S. chemical companies would like to forget. Prices were up, but production and demand were down from the year before. Before year's end, markets sagged again from renewed recession.

Thanks to some price increases, the 50 largest U.S. chemical producers (ranked by chemical sales) were able to make a 7.6% gain in chemical sales to a total of almost $114 billion in 1981. Although U.S. chemical production was falling, the average chemicals and allied products price index from the Commerce Department was up 10.7% in 1981 from 1980. Hence, 1981 was the second year in a row that chemical dollar sales increased while production fell.

But even though sales were up in 1981, operating profits were not. For the 45 companies in the Top 50 that reported operating profits for their chemical businesses in 1981, the total fell 8.4% from 1980 to $8.28 billion. Operating profits are pretax, preinterest cost, and precorporate overhead. This means that the chemical operating profit margin for those 45 companies dropped to 7.7% in 1981 from 9.0% in 1980.

Although profits were slumping, companies still were putting more money into their chemical operations. Chemical assets, for the 46 companies that reported them, grew an average of 8.3% to $86.2 billion from 1980. But once again, rising assets and falling operating profits took their toll on chemical profitability. The operating return on chemical assets decreased in 1981 to 8.4% from 11.5% in 1980.

All but one of the companies on C&EN's Top 50 producers list for 1981 were repeaters from 1980. The only addition this year is Sun Co., which has been omitted in past tallies for lack of data. Sun, which ranked 46th in 1981, would have been 47th if it had been included in 1980's list.

About the Top 50 chemical producers

This year, there is a revised format for the Top 50 U.S. chemical producers. The new presentation goes into much more detail on performance of purely chemical operations, enabled by product-line financial breakdowns given in the companies' reports to their stockholders.

Besides breaking out chemical sales for the companies, the Top 50 compilation now identifies chemical operating profits and chemical assets, plus rates of chemical return. In the past, chemical sales had been sought out but conventional total company data had been used for the other measures.

To expand on performance in chemicals, however, the Top 50 report now is less precise for some companies in the exact makeup of chemical operations. Many firms include some nonchemical operations with chemicals in their product-line financial data. In the past, wherever possible, these nonchemical units were eliminated from the chemical sales figure.

Profitability can mean several things. These measures include:

- Operating profit—sales minus selling and administrative expenses and the cost of goods.
- Operating profit margin—operating profit as a percentage of sales.
- Identifiable chemical assets—tangible assets associated with the production of chemicals within a company. In cases in which the company may have 100% chemical sales and profits, C&EN has, where possible, eliminated corporate assets not associated with production. In this way, chemical assets will not equal 100% of total assets in most instances.
- Return on chemical assets—chemical operating profit as a percentage of identifiable chemical assets.

Sun has replaced Texasgulf on the list this year. Texasgulf, acquired last year by the French company Société Nationale Elf Aquitaine, no longer publishes sales figures at all. If it did, it undoubtedly would qualify for the Top 50. Other companies would be listed if they divulged pure chemical sales. Among these are Goodyear and ICI Americas.

In spite of the modest increase in total Top 50 sales in 1981, some companies managed to rise considerably above the average.

The largest sales increase was at American Hoechst—24.1% to $1.39 billion. This propelled the U.S. arm of West Germany's Hoechst to 26th place on the list from 33rd in 1980, the biggest leap in rank for any of the 50 companies.

Mobil was another company with good chemical sales growth last year, up 23.0% to almost $2.33 billion. However, its operating profits for chemicals, struck by hard times in the petrochemicals and plastics industries, dropped 30.3% to $122 million. Likewise, Atlantic Richfield had a 21.7% increase in chemical sales in 1981 to $2.74 billion, but chemical operating profits fell 88% to $16 million.

The largest company in the Top 50, Du Pont, also performed well ahead of the average in 1981. Its chemical sales were $12.2 billion, a 14.1% increase over 1980. Operating profit from chemical operations also rose healthily—15.8% to $1.16 billion. Part of this increase is due to the inclusion of acquired Conoco's chemical operations in the latter part of the year. But another influence was a stabilizing in fibers markets during 1981.

Another company that benefited from the stabilized fiber markets is Celanese, whose 1981 sales increased 15.0% to $3.69 billion while chemical operating profits went up 21.5%.

One market, fertilizer, that helped many companies in 1980, hurt them in 1981. For example, chemical sales at CF Industries dropped 14.5% in 1981 to $1.05 billion, while chemical operating profits fell 66.1% to $81 million. The same situation hit Williams Cos. at its big Agrico Chemical operation. Williams' chemical sales

More than half of Top 50 chemical makers had earnings drops last year

Rank 1981	Rank 1980[a]	Company	Chemical sales 1981 ($ millions)	Change from 1980	Chemical sales as % of total sales	Industry classification	Chemical operating profits[b]	Change from 1980	Chemical operating profits as % of total operating profits	Operating profit margin[c]	Identi-fiable chemical assets	Chemical assets % of total assets	Operating return on chemical assets[d]
1	1	**Du Pont**	$12,189	14.1%	53.4%	Basic chemicals	$1155	15.8%	40.5%	9.5%	$8268	37.9%	14.0%
2	2	**Dow Chemical**	9,387[e]	7.7	79.3	Basic chemicals	612	−37.0	66.8	6.5	8636	69.1	7.1
3	3	**Exxon**	8,449	2.7	7.5	Petroleum	271	−32.6	5.0	3.2	4937	7.8	5.5
4	4	**Monsanto**	6,311[e]	5.5	90.8	Basic chemicals	672	273.3	90.8	10.6	5224	86.1	12.9
5	5	**Union Carbide**	5,575	6.9	54.3	Basic chemicals	580	−12.3	39.3	10.4	6008	65.4	9.7
6	6	**Celanese**	3,691	15.0	93.4	Basic chemicals	198	21.5	90.0	5.4	2450	81.9	8.1
7	7	**Shell Oil**	3,578	12.8	16.5	Petroleum	15	−91.4	0.4	0.4	3462	18.8	0.4
8	8	**Standard Oil (Ind.)**	3,088	7.6	9.7	Petroleum	210	−24.2	5.5	6.8	3792	12.3	7.6
9	13	**Atlantic Richfield**	2,739	21.7	9.7	Petroleum	16	−88.0	0.5	0.6	2728	13.8	0.6
10	9	**W. R. Grace**	2,666	−1.1	41.9	Specialty chemicals	379	−1.0	47.2	14.2	1721	35.9	22.0
11	10	**Allied**	2,653	8.3	41.4	Basic chemicals	189	2.2	17.6	7.1	1810	33.9	10.4
12	14	**Phillips Petroleum**	2,470	9.8	15.5	Petroleum	140	−13.6	5.1	5.7	1544	16.1	9.1
13	11	**Gulf Oil**	2,412	−1.1	8.0	Petroleum	−59	def	def	def	1701	8.3	def
14	12	**Occidental Petroleum**	2,406	−0.8	15.7	Petroleum	108	−15.0	4.8	4.5	1922	25.9	5.6
15	16	**Eastman Kodak**	2,349	13.5	22.7	Photo equipment	289	−8.8	14.0	12.3	1680	17.8	17.2
16	17	**Mobil**	2,325	23.0	3.4	Petroleum	122	−30.3	2.0	5.2	1797	5.2	6.8
17	15	**Hercules**	2,273	8.5	83.6	Basic chemicals	170	28.8	94.4	7.5	1534	91.5	11.1
18	18	**American Cyanamid**	1,945[e]	4.5	53.3	Basic chemicals	198	10.0	56.1	10.2	1488	60.1	13.3
19	20	**Rohm & Haas**	1,761	9.5	93.4	Basic chemicals	187	−3.6	106.9	10.6	1109	97.9	16.9
20	19	**Stauffer Chemical**	1,726	1.8	100.0	Basic chemicals	261	34.5	100.0	15.1	1638	80.5	15.9
21	21	**Tenneco**	1,589	−3.1	10.3	Petroleum	36	−58.1	1.9	2.3	1244	7.4	2.9
22	25	**Texaco**	1,525	13.3	2.6	Petroleum	143	11.7	2.3	9.4	1062	3.9	13.5
23	23	**Ethyl Corp.**	1,515[e]	−0.1	86.2	Basic chemicals	154	0.7	85.6	10.2	958	75.9	16.1
24	24	**U.S. Steel**	1,427	−0.7	10.2	Steel	11	−84.5	1.6	0.8	727	5.5	1.5
25	22	**Borden**	1,424[e]	−8.0	32.3	Dairy products	141	−22.5	45.8	9.9	1144	49.2	12.3
26	33	**American Hoechst**	1,391	24.1	86.5	Basic chemicals	na	na	na	na	na	na	na
27	28	**FMC**	1,383	13.5	41.1	Machinery	195	72.6	62.7	14.1	1114	40.7	17.5
28	26	**Air Products**[i]	1,362	7.9	86.8	Basic chemicals	204	4.6	87.2	15.0	1499	79.9	13.6
29	32	**International Minerals**[g]	1,347	17.7	48.6	Agri. chemicals	254	−4.9	78.4	18.9	1384	70.1	18.4
30	34	**Ashland Oil**	1,330	20.8	13.7	Petroleum	41	−30.5	23.0	3.1	463	11.3	8.9
31	29	**Ciba-Geigy**	1,297	9.7	69.7	Specialty chemicals	na	na	na	na	na	na	na
32	37	**Mobay Chemical**	1,270	18.8	100.0	Basic chemicals	na	na	100.0	na	1303	100.0	na
33	36	**Union Oil of Calif.**	1,248	14.8	11.0	Petroleum	111[h]	6.7	14.0	8.9	701	9.2	15.8
34	31	**Standard Oil of Calif.**	1,219	5.5	2.7	Petroleum	31[h]	−8.8	1.3	2.5	917	3.9	3.4
35	35	**Diamond Shamrock**	1,152	4.9	34.1	Basic chemicals	150	32.7	40.7	13.0	1075	35.6	14.0
36	41	**Olin**	1,077	16.6	53.8	Basic chemicals	80	27.0	44.2	7.4	947	60.9	8.4
37	27	**CF Industries**	1,054[e]	−14.5	100.0	Agri. chemicals	81	−66.1	100.0	7.7	1133	100.0	7.1
38	38	**B. F. Goodrich**	1,050	2.7	33.0	Rubber products	48	−20.0	43.6	4.6	1261	46.7	3.8
39	39	**PPG Industries**	1,012	5.0	30.2	Glass products	120	−16.7	31.9	11.9	1004	34.0	15.8
40	30	**Williams Cos.**	985[e]	−15.9	49.8	Agri. chemicals	35	−80.1	22.9	3.6	1018	41.6	3.4
41	40	**BASF Wyandotte**	967	5.3	100.0	Basic chemicals	24	84.6	100.0	2.5	791	100.0	3.0
42	43	**Reichhold Chemicals**	950	7.3	100.0	Basic chemicals	35	29.6	100.0	3.7	401	98.0	8.7
43	42	**Lubrizol**	899	−2.5	100.0	Specialty chemicals	149	−22.0	100.0	16.6	582	86.5	25.6
44	44	**National Distillers**	823	−1.0	40.0	Alcoholic beverages	134	6.3	71.3	16.3	606	36.1	22.1
45	45	**Farmland Industries**	816	11.2	14.8	Agricultural supplies	67	−40.7	31.2	8.2	454	24.2	14.8
46	47	**Sun Co.**	746	12.9	5.0	Petroleum	na	na	na	na	na	na	na
47	47	**Georgia-Pacific**	738[e]	11.6	13.6	Wood products	149	−2.6	37.6	20.2	947	18.7	15.7
48	46	**Dow Corning**	722	5.9	100.0	Specialty chemicals	76	2.7	100.0	10.5	787	100.0	9.7
49	50	**Nalco Chemical**	667	8.1	100.0	Specialty chemicals	122	6.1	100.0	18.3	227	75.1	34.9
50	49	**Borg-Warner**	664	5.2	24.0	Auto equipment	61	3.4	29.6	9.2	316	22.5	19.3

a Revised. **b** Operating profit defined as sales less administrative expense and cost of selling. **c** Operating profit as a percentage of chemical sales. **d** Operating profit as a percentage of identifiable chemical assets. **e** Chemical sales include significant amounts of nonchemical products. **f** Fiscal year ended Sept. 30, 1981. **g** Fiscal year ended June 30, 1981. **h** Net income. **i** Fiscal year ended Aug. 31, 1981. **na** = not available. **def** = deficit.

Different companies lead in profits, assets, and profitability

Rank		Operating profit ($ millions)		Operating profit margin[a]		Chemical assets ($ millions)		Return on chemical assets[b]
1	Du Pont	$1155	Georgia-Pacific	20.2%	Dow Chemical	$8636	Nalco Chemical	34.9%
2	Monsanto	672	International Minerals	18.9	Du Pont	8268	Lubrizol	25.6
3	Dow Chemical	612	Nalco Chemical	18.3	Union Carbide	6008	National Distillers	22.1
4	Union Carbide	580	Lubrizol	16.6	Monsanto	5224	W. R. Grace	22.0
5	W. R. Grace	379	National Distillers	16.3	Exxon	4937	Borg-Warner	19.3
6	Eastman Kodak	289	Stauffer Chemical	15.1	Shell Oil	3791	International Minerals	18.4
7	Exxon	271	Air Products	15.0	Standard Oil (Ind.)	2766	FMC	17.5
8	Stauffer Chemical	261	W. R. Grace	14.2	Atlantic Richfield	2728	Eastman Kodak	17.2
9	International Minerals	254	FMC	14.1	Celanese	2450	Rohm & Haas	16.9
10	Standard Oil (Ind.)	210	Diamond Shamrock	13.0	Occidental Petroleum	1922	Ethyl Corp.	16.1
11	Air Products	204	PPG Industries	11.9	Allied	1810	Air Products	15.9
12	Celanese	198	Monsanto	10.6	W. R. Grace	1721	PPG Industries	15.8
13	American Cyanamid	198	Rohm & Haas	10.6	Gulf Oil	1701	Farmland Industries	14.8
14	FMC	195	Dow Corning	10.5	Eastman Kodak	1680	Du Pont	14.0
15	Allied	189	Union Carbide	10.4	Stauffer Chemical	1638	Diamond Shamrock	14.0

a Chemical operating profit as a percentage of chemical sales. b Chemical operating profit as a percentage of identifiable chemical assets.

fell 15.9% to $985 million and chemical operating profits dropped 80.1% to $35 million.

These sales declines were enough to drop both companies a rugged 10 places in the Top 50 rankings—CF Industries to 37th in 1981 from 27th in 1980 and Williams to 40th last year from 30th the year before.

It must be admitted that chemical producers report their chemical results in different ways. Chemical sales or operating profit at one company may not compare exactly with figures from another. In fact, there are changes within an individual company year-to-year. Thus, the rankings in the Top 50 list are approximate. They should be used as a general guide to the relative performance of the various companies. □

Basic chemical companies as a group outperform others

It may seem logical, but it still needs proof that basic chemical companies know more about making and selling chemicals than do other companies that get into the business.

It certainly seems true from last year's results, in a year when the economy first was becalmed and then beset with recession. True, basic chemical companies were not the best performers in every category, but where they did not lead, they were usually a respectable second.

For comparison, C&EN used 44 of the 50 companies that had fairly consistent reporting. The 44 have similar accounting for chemical sales, chemical operating profits, and chemical assets. The 44 companies had combined chemical sales in 1981 of $107 billion, or 95% of the total for the Top 50. Of the 44, 23 were basic chemical companies with combined chemical sales of $63.4 billion, 59% of total chemical sales of the 44. Eleven were oil companies with sales of $31.9 billion, or 30%. The other 10 companies had chemical sales of $11.7 billion, or 11%.

Chemical sales of the 23 chemical companies and 11 oil companies both increased 8% in 1981 from 1980. For the remaining 10 companies, chemical sales went up a smaller 5%.

It is in operating profits that the 23 chemical companies shine. Their chemical operating profits increased 2% from 1980 to $5.95 billion. The gain wasn't much, but it was far better than the 41% drop in chemical operating profits to $1.04 billion for the oil companies. Chemical earnings for the other 10 declined 9% to $1.22 billion.

The one area in which chemical companies truly lagged last year was asset growth: Chemical assets of the 23 chemical companies grew just 7% in 1981 to $51.3 billion. However, chemical assets of the oil companies increased 9% to $24 billion, and those of the other 10 companies rose 13% to $9.25 billion.

In profitability, the chemical companies came in well ahead of the oil companies and a decent second to the other producers. Average chemical operating profit margin for the 23 chemical firms was 9.4% in 1981, compared to 3.3% for the oil companies, but below 10.4% for the remaining companies.

The same held true for return on assets for chemical operations. For the 23 chemical companies, it was 11.6%, compared to 4.3% for the oil companies and 13.1% for the others.

$ Millions	Chemical sales	Change from 1980	Chemical operating profits	Change from 1980	Chemical profit margin[a]	Chemical assets	Change from 1980	Chemical return on assets[b]
23 chemical companies[c]	$ 63,422	8%	$5947	2%	9.4%	$51,327	7%	11.6%
11 oil companies[c]	31,911	8	1043	−41	3.3	23,995	9%	4.3
10 other	11,686	5	1215	−9	10.4	9,253	13	13.1
TOTAL[c]	**$107,019**	**7%**	**$8205**	**−9%**	**7.7%**	**$84,575**	**8%**	**9.7%**

a Chemical operating profits as a percentage of chemical sales. b Chemical operating profits as a percentage of identifiable chemical assets. c Three chemical companies—Ciba-Geigy, American Hoechst, and Dow Corning—and three oil companies—Standard Oil of California, Union Oil of California, and Sun Co.—have been excluded.

World plastics capacity due up 17% by mid-80s

As the great business plateau starting in 1979 stretches interminably through the early 1980s, it would seem that the last thing one of the most struggling parts of the world-wide chemical industry needs is more plants. But for plastics, that's exactly what's in store—17% more capacity by the mid-1980s, according to a new worldwide study by consultants C. H. Kline of Fairfield, N.J.

Capacity is just one of the subjects of Kline's 715-page, two-volume report on the worldwide plastics industry, which covers more than 600 producers in the noncommunist world. Other highlights:

- Low-density polyethylene finally will become the world's largest-volume resin, passing polyvinyl chloride.
- Dow Chemical ranks number one among more than 600 plastics producers, with BASF and Shell not far behind.
- The U.S. is the leading plastics producer with one third of worldwide capacity. The U.S. also has the most plastics companies with 102.
- The fastest-growing plastic by far will be the new linear low-density polyethylene, which will triple capacity by the mid-1980s.
- Most notable geographic growth in plastics will be in developing countries, whose share of the market will be nearly one fourth by the mid-1980s.

The Kline study pegs known 1981 capacity for 20 leading plastics at a little more than 140 billion lb (63.7 million metric tons). This capacity will bulge 17.4% by the mid-1980s to almost 165 billion lb (74.8 million metric tons).

This growth will center in terms of resins in the polyolefins and geographically in the developing countries. However, there will be great differences in growth rates.

For example, for the two resins now way out in front in capacity—low-density polyethylene and polyvinyl chloride—Kline forecasts that the former will grow twice as fast as the latter. In the process, they will trade places. Kline says that conventional LDPE (not including the new linear grades) still will grow 20.0% in worldwide capacity in the first half of the 1980s to 38.0 billion lb. This will give it top spot, ahead of PVC, which Kline predicts will grow only 8.9% in capacity to 35.3 billion lb.

Among the other top resins, Kline rates the industry's wonder child, linear LDPE, almost at 203% growth over this half-decade to 8.08 billion lb from a starting position of 2.67 billion lb in 1981. The study also gives high-density polyethylene good growth potential with a 26.7% capacity jump to 22.9 billion lb by the mid-1980s. HDPE will keep third place among resins.

Two other products with double-digit growth will be polypropylene and polyurethane-precursor isocyanates. Kline says polypropylene capacity is due up 13.9% by mid-decade to 17.8 billion lb. Polypropylene will hop up from fifth to fourth place. Isocyanates plant capacity will grow 17.4% to 4.27 billion lb.

Losing position in the first half of the 1980s will be the aromatics. The Kline report forecasts some growth for polystyrene capacity, 6.9% to 17.6 billion lb. But polystyrene will drop from fourth to fifth position among resins.

The investment trend for these resins will be in developing countries. Plastics capacity outside the 10 leading industrial countries will grow 69% in just half a decade, according to Kline's data.

Among the 10 leading countries, the U.S. had about 40 billion lb of plastics capacity in 1981. Japan was second with more than 15 billion lb, and West Germany third with more than 11 billion lb. □

Dow Chemical is world's leading plastics producer

Known capacity 1981 (millions of lb per year)[a]	Major thermo-plastics[b]	Other plastics[c]	Total
Dow Chemical	6338	1566	7904
BASF	6024	1573	7597
Shell	6932	486	7418
ICI	6030	653	6683
Hoechst	6259	132	6391
Union Carbide	4840	471	5311
Montedison	3410	1019	4429
Solvay	4356	—	4356
Du Pont	2794	968	3762
British Petroleum	3302	209	3511
Monsanto	1896	1107	3003
CdF Chimie	2772	150	2922
B. F. Goodrich	2895	—	2895
Mitsubishi	2572	291	2863
Bayer	660	2198	2858
Exxon	2585	—	2585
Phillips Petroleum	1962	271	2233
Huels	2121	68	2189
National Distillers	2013	—	2013
DSM	1892	88	1980

a Most companies also have unknown capacities in smaller-volume plastics. **b** Low-density polyethylene, high-density polyethylene, polypropylene, polystyrene, and polyvinyl chloride. **c** Includes polyurethane chemicals. **Source:** C. H. Kline consultants

Largest-volume plastic in the world by middle of decade will be low-density polyethylene

Rank			Capacity, millions of lb per year		
Mid-1980s	1981	Resin	Mid-1980s	1981	Change
1	2	**Polyethylene, low-density**	38,047	31,702	20.0%
2	1	**Polyvinyl chloride**	35,339	32,430	8.9
3	3	**Polyethylene, high-density**	22,895	18,071	26.7
4	5	**Polypropylene**	17,809	15,631	13.9
5	4	**Polystyrene**	17,626	16,491	6.9
6	10	**Polyethylene, linear low-density**	8,081	2,669	202.8
7	6	**Acrylonitrile-butadiene-styrene**	4,662	4,374	6.6
8	8	**Isocyanates[a]**	4,270	3,634	17.4
9	7	**Polyols[a]**	4,255	4,246	0.2
10	9	**Unsaturated polyesters**	3,538	3,516	0.6
		Other[b]	8,006	7,359	8.8
		TOTAL	**164,528**	**140,123**	**17.4%**

a Used as indicators for derivative polyurethanes. **b** Includes acrylics, amino resins, cellulosics, fluoropolymers, phenolics, polyacetals, polycarbonates, polyphenylene oxide, styrene-acrylonitrile. **Source:** C. H. Kline consultants

Second 50 companies—
New breakdowns for chemicals
Page 21

Chemical & Engineering NEWS

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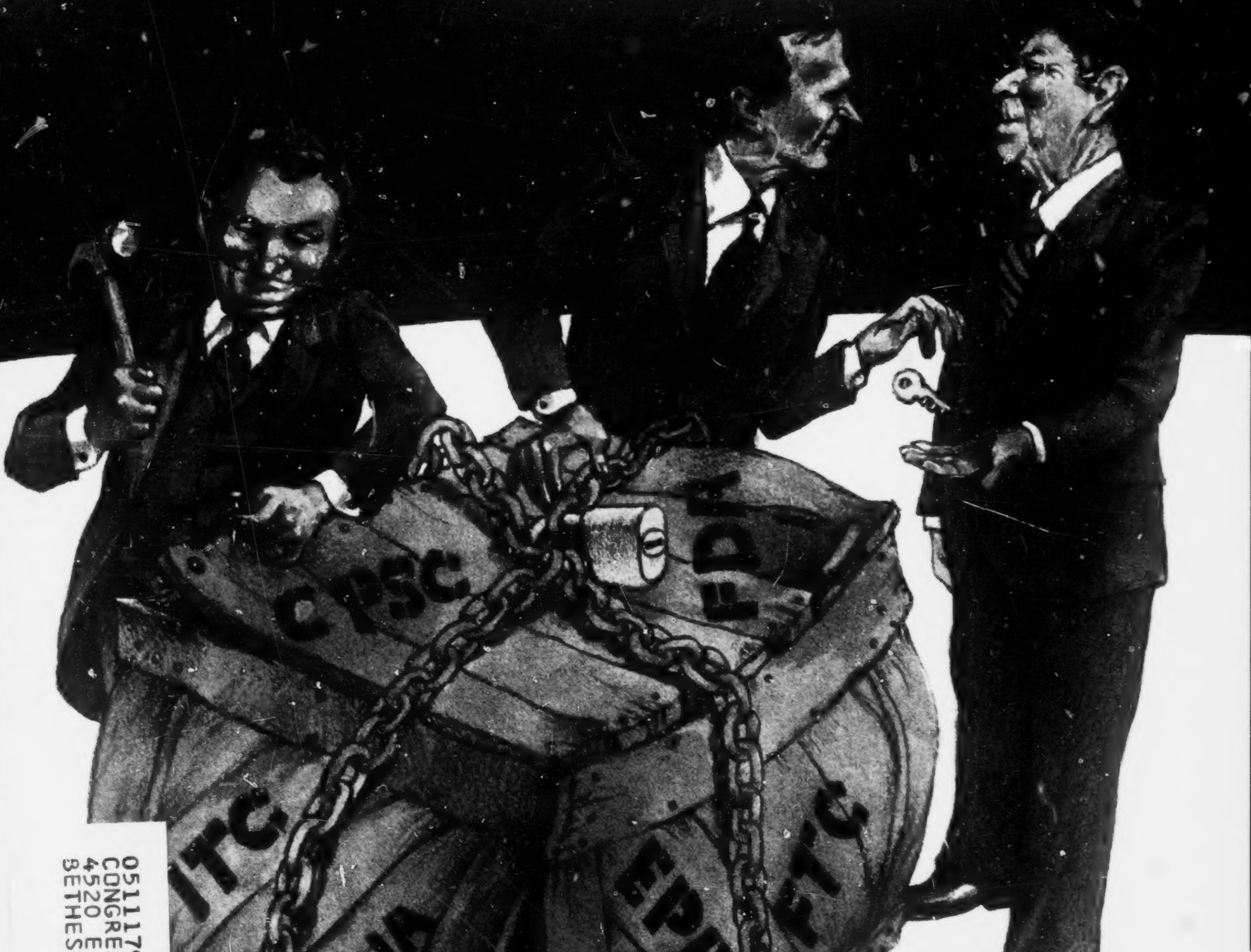

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Deregulation

Amid the turmoil,
there's definite change
Page 13

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Chemical & Engineering NEWS

4 Letters

Concentrates
18 Business
32 Government
42 Science/Technology

The Departments
36 New Products
57 Meetings
68 Newscripts

News of the Week

- ***Exxon, Canadian consortium*** *halt their synthetic fuels projects.* ***Page 10***
- ***Conoco merger was profitable*** *for Du Pont, stockholders learn.* ***Page 11***
- ***Allied, Emerson Electric*** *to make motors from amorphous metal alloys.* ***Page 11***
- ***Second Annual Report on Carcinogens*** *from Health & Human Services Department lists 88 substances.* ***Page 11***
- ***U.S./Canada talks on acid rain*** *held up by U.S. insistence that all scientific work be subjected to peer review.* ***Page 12***
- ***Union Carbide is withdrawing*** *as contractor for Department of Energy's nuclear facilities in Tennessee and Kentucky.* ***Page 12***

News Focus

- ***Regulatory reform*** *is changing the way federal agencies operate, though not everyone agrees it is an improvement.* ***Page 13***

Business

- ***Chemical producers in C&EN's Second 50*** *list increased sales 11% over 1980, a better showing than the Top 50.* ***Page 21***

International

- ***International Register of Potentially Toxic Chemicals*** *will issue data profiles on 330 substances compiled to date.* ***Page 25***
- ***U.S. chemical spending overseas*** *is slated to increase 27% over 1981 figure, Commerce Department survey shows; Canada will get the largest share.* ***Page 27***

Science Policy

- ***Council of Scientific Society Presidents,*** *despite indifference from the elite organizations in the science community, is making impressive progress.* ***Page 43***

Education

- ***Center for History of Chemistry,*** *sponsored by ACS and University of Pennsylvania, aims to give public better appreciation of chemistry's significance.* ***Page 46***

Technology

- ***Photosynthetic bacterium*** *removes sulfurous gases and carbon dioxide from industrial gas streams.* ***Page 49***

Books

- ***"Kennedy, Khrushchev, and the Test Ban,"*** *by Glenn Seaborg and Benjamin Loeb, recounts events leading up to signing the 1963 treaty banning nuclear tests.* ***Page 51***

ACS News

- ***ACS Board*** *approves 89 Petroleum Research Fund grants-in-aid, approves increase in PRF budget.* ***Page 53***

Medium-sized chemical firms post fair year

Second 50 recorded sales in 1981 up 11% to nearly $20 billion, about even with chemical inflation of 10.7%; profits increased just 3%

William J. Storck
C&EN, New York

Granted that very few companies in the chemical industry did well in 1981, the medium-sized chemical producers that make up C&EN's list of the Second 50 chemical makers in the U.S. (those ranking 51 to 100 in terms of chemical sales) at least had a sales performance that kept pace with inflation. And they outperformed the 50 largest U.S. chemical producers by far (C&EN, May 3, page 14).

Combined sales for the Second 50 totaled $19.9 billion in 1981, an 11% increase over these same companies' sales in 1980. Since chemical inflation in 1981 averaged about 10.7%, this means that actual shipments of the Second 50 companies were about even with those in 1980.

Operating profits, for the smaller companies that disclose such figures and for which comparable year-to-year amounts can be obtained, increased just 3% to $1.74 billion last year.

Investment in chemical activity continued to improve, in spite of relatively poor performance in earnings. Identifiable chemical assets at the companies that broke out such numbers increased 9% in 1981 to $12.1 billion.

As a result of both sales and assets increasing faster than earnings, profitability in 1981 fell from 1980. Operating profit margins (operating profits as a percentage of chemical sales) dropped to 10.7% in 1981 from 12.1% in 1980. Return on assets (operating profit as a percentage of identifiable assets) for the group dropped to an average of 14.0% last year from 14.7% in 1980.

The group of companies making up the Second 50 this year has changed slightly from last year. Not included this year are Texasgulf, which was acquired by France's Elf Aquitaine and no longer discloses operational figures, and Northwest Industries, which has changed its methods of reporting so that chemical sales figures are not available.

Two new companies are on the list. Beatrice Foods' chemical sales were large enough to warrant inclusion in past years, but the company inadvertently was omitted. And Tyler has changed its method of accounting so that chemical sales figures are available; they had not been in past years.

Other companies have chemical sales large enough to qualify them for ranking, but, like Texasgulf and Northwest Industries, they do not

Second 50 companies outperform the Top 50

About the only two respects in which the Second 50 chemical producers are the same as the Top 50 is that 50 companies are in both groups and that all of them make and sell chemicals. But the similarities end there.

Even superficially, the differences in the makeup of the two tabulations are quite evident. Of the 50 smaller chemical producers, 23 can be classified as chemical companies, compared with 26 of the Top 50 companies (C&EN, May 3, page 9).

Oil producers and natural gas companies account for only eight of the companies on the list of smaller producers, whereas 14 of the Top 50 are oil and natural gas producers. And of the Second 50, a full 19 can be classified as diversified manufacturers or manufacturers of principal product lines other than chemicals; only 10 of the Top 50 fall into this classification. Seven of the Second 50 companies are foreign-owned, compared with just four of the Top 50.

It is performance, however, where the Second 50 shines. Perhaps this is because the companies making up the list produce more high-value-added specialty chemicals, or perhaps it is because their product lines are less diverse and thus they can adapt to changes in the economy with greater speed. Whatever the reason, while the giants of the industry were racking up a 7% increase in sales last year, sales for the Second 50 were growing 11%. And while operating profits at the Top 50 were falling 9% in 1981 from the year before, operating profits at the Second 50 were increasing 3%.

The identifiable chemical assets for both groups increased about equally in 1981—9% for the Second 50 and 8% for the Top 50 chemical producers. Assets and operating profit growth do not include all of the companies in the list, but only those for which comparable data can be obtained.

The smaller producers in general also were more profitable than the larger chemical makers. Operating profit margin (operating profits as a percentage of sales) for chemicals for the Second 50 was 10.7%, compared with 7.7% for the Top 50. And average return on assets (operating profits as a percentage of identifiable assets) for the Second 50 was 14.0%, whereas that for the Top 50 was just 9.7%.

	Second 50	Top 50	Combined 100
Chemical sales, change from 1980	11%	7%	8%
Chemical operating profits, change from 1980	3	−9	−7
Chemical assets, change from 1980	9	8	8
Chemical operating profit margin 1981	10.7	7.7	8.1
Return on identifiable chemical assets 1981	14.0	9.7	10.2
	Number of companies on list		
Chemical companies	23	26	49
Petroleum and natural gas producers	8	14	22
Diversified and other	19	10	29
Foreign owned	7	4	11

Chemical sales totaled almost $20 billion at Second 50 chemical producers

Rank 1981	Rank 1980[a]	Company	Chemical sales 1981 ($ millions)	Change from 1980	Chemical sales as % of total sales	Industry classification	Chemical operating profits[b]	Change from 1980	Chemical operating profits as % of total operating profits	Operating profit margin[c]	Identifiable chemical assets	Chemical assets % of total assets	Operating return on chemical assets[d]
51	54	**Akzona**	$694	20.9%	58.4%	Basic chemicals	$ 25	def	46.3%	3.6%	$432	51.7%	5.8%
52	52	**Koppers**	678[e]	17.5	33.6	Diversified chemicals	29	−38.3%	20.4	4.3	377	28.4	7.7
53	53	**Merck**	664[e]	15.5	22.7	Drugs	73	25.9	12.6	11.0	547	16.5	13.3
54	51	**Pennwalt**	641	7.7	60.7	Basic chemicals	73	43.1	60.3	11.4	436	68.3	16.7
55	64	**El Paso**	576	22.6	14.7	Natural gas	13	−61.8	3.0	2.3	425	11.5	3.1
56	61	**Uniroyal**	573	17.4	25.4	Tires	79	−23.3	50.6	13.8	415	28.5	19.0
57	55	**NL Industries**	565	2.4	22.9	Petroleum services	77	40.0	15.3	13.6	358	15.6	21.5
58	65	**Badische**	563	24.3	100.0	Basic chemicals	25	13.6	100.0	4.4	410	100.0	6.1
59	62	**Esmark**[f]	561[e]	15.4	17.9	Food	47	nc	24.4	8.4	354	20.3	13.3
60	56	**Freeport-McMoRan**	554	5.1	66.3	Agricultural chemicals	148	9.6	62.2	26.7	313	21.1	47.3
61	57	**Aluminum Co. of America**	553[e]	5.7	11.0	Nonferrous metals	na	na	na	na	na	na	na
62	59	**Kerr-McGee**	543	8.4	14.2	Petroleum	35	−5.4	7.2	6.4	685	20.1	5.1
63	60	**Kaiser Aluminum**	533	8.6	16.5	Nonferrous metals	74	39.6	26.7	13.9	481	12.5	15.4
64	65	**Witco Chemical**	510	12.6	39.5	Specialty chemicals	48	37.1	43.2	9.4	239	33.0	20.1
65	69	**Airco**	500	19.0	41.7	Basic chemicals	na	na	na	na	na	na	na
66	68	**Cabot**[g]	492	11.6	30.3	Specialty metals	66	nc	26.7	13.4	286	22.7	23.1
66	58	**Eli Lilly**	492	−5.0	17.7	Drugs	na	na	na	na	na	na	na
68	63	**Standard Oil (Ohio)**	481	1.1	3.5	Petroleum	34	−39.3	0.8	7.1	525	3.3	6.5
69	67	**International Flavors**	451	0.7	100.0	Specialty chemicals	102	−3.8	100.0	22.6	375	87.0	27.2
70	73	**National Starch**	450	25.3	67.4	Specialty chemicals	na	na	na	na	na	na	na
71	71	**Beatrice Foods**	446	14.7	4.9	Food	63	26.0	3.3	14.1	na	na	na
72	70	**Pfizer**	421	1.2	13.0	Drugs	−4	def	def	def	446	12.2	def
73	75	**Mississippi Chemical**[h]	395	14.8	100.0	Farm cooperative	61	24.5	100.0	15.4	303	71.8	20.1
74	83	**Polysar**	395	45.8	100.0	Basic chemicals	12	100.0	100.0	3.0	180	100.0	6.7
75	72	**Internorth**	368	2.2	10.1	Natural gas	49	−29.0	11.6	13.3	407	10.7	12.0
76	77	**American Petrofina**	335	5.7	13.4	Petroleum	8	−57.9	6.4	2.4	248	21.6	3.2
77	78	**Liquid Air**	327	4.8	80.1	Basic chemicals	46	4.5	90.2	14.1	378	78.1	12.2
78	79	**GAF**	325	5.5	48.3	Diversified chemicals	57	9.6	def	17.5	201	35.9	28.4
79	76	**Upjohn**	324	−0.6	17.1	Drugs	4	−85.7	1.5	1.2	194	10.0	2.1
80	84	**Terra Chemicals**	317[e]	19.6	100.0	Agricultural chemicals	na	na	na	na	na	na	na
80	81	**Thiokol**	317	11.2	44.0	Aerospace	31	−3.1	50.0	9.8	291	62.2	10.7
82	92	**First Mississippi**[h]	308	39.4	86.0	Agricultural chemicals	44	25.7	73.3	14.3	163	51.1	27.0
83	86	**Rhône-Poulenc**	300	17.6	100.0	Specialty chemicals	na	na	na	na	na	na	na
84	88	**Vulcan Materials**	299	19.1	38.2	Nonmetallic minerals	71	42.0	52.6	23.7	236	35.0	30.1
85	87	**H. B. Fuller**[i]	280	11.1	85.1	Specialty chemicals	na	na	na	na	na	na	na
86	85	**Martin Marietta**	277	7.4	13.6	Aerospace	48	−3.1	23.1	11.8	212	22.9	12.6
86	—	**Tyler**	277	na	35.9	Diversified chemicals	26	na	32.9	9.4	163	36.1	16.0
88	82	**Emhart**	270	−3.9	15.5	Machinery	27	12.5	16.4	14.0	111	10.4	24.3
89	94	**Big Three Industries**	265	28.6	32.2	Petroleum services	79	27.4	39.1	29.8	505	49.8	15.6
90	89	**SCM**[h]	263[e]	6.5	13.6	Paint	31	−3.1	23.1	11.8	247	22.9	12.6
91	90	**Petrolite**[f]	261	12.0	87.9	Specialty chemicals	41	5.1	89.1	15.7	158	79.8	25.9
92	74	**Soltex**	250	−28.6	100.0	Basic chemicals	na	na	na	na	na	na	na
93	92	**Houston Natural Gas**[j]	248	21.4	1.6	Natural gas	14	−26.3	0.6	6.9	368	16.7	7.3
94	90	**Cities Service**	240	3.0	2.8	Petroleum	5	−68.8	0.8	2.1	340	5.6	1.5
95	96	**Engelhard**	240[e]	21.8	10.9	Specialty metals	47	30.6	44.8	19.6	203	28.8	23.2
96	80	**Beker Industries**	235	−20.3	100.0	Agricultural chemicals	na	na	na	na	na	na	na
97	95	**Loctite**[h]	214	7.4	100.0	Specialty chemicals	24	−33.3	100.0	11.2	195	107.7	12.3
98	50	**Stepan Chemical**	205	29.7	100.0	Specialty chemicals	13	116.7	100.0	6.3	[illegible]	100.0	7.4
99	48	**Getty Oil**	204	21.4	1.6	Petroleum	14	−26.3	0.6	6.9	na	na	na
100	49	**Agway**	200	21.2	9.7	Farm cooperative	na	na	na	na	na	na	na

a Revised. **b** Operating profit is defined as sales less administrative expense and cost of selling. **c** Operating profit as a percentage of chemical sales. **d** Operating profit as a percentage of identifiable chemical assets. **e** Chemical sales include significant amounts of nonchemical products. **f** Fiscal year ended Oct. 31, 1981. **g** Fiscal year ended Sept. 30, 1981. **h** Fiscal year ended June 30, 1981. **i** Fiscal year ended Nov. 30, 1981. **j** Fiscal year ended July 31, 1981. **na** = not available. **nc** = no change. **def** = deficit.

break out these figures. Among these companies are 3M, Dart & Kraft, Gulf & Western, General Tire, and St. Joe Minerals.

Many of the companies on the list outperformed the averages by a wide margin. The largest sales increase was posted by the U.S. operations of Canada's Polysar, whose chemical sales increased 45.8% from 1980 to $395 million. Polysar's increase took it to 73rd on the list from 83rd in 1980. First Mississippi, whose sales increased 39.4% to $308 million, also advanced 10 places to 82nd in 1981 from 92nd place the year before.

Other companies with healthy sales gains include Stepan Chemical with a 29.7% gain; Big Three Industries, 28.6%; and Unilever's U.S. subsidiary National Starch, 25.3%.

In operating profit gains, Stepan Chemical was the leader, increasing almost 117% to $13 million. And Polysar doubled its chemical operating profits to $12 million from the year before.

A clutch of companies had increases in operating profits of about 40%. Pennwalt's operating profits increased 43.1% to $73 million, Vulcan Materials' 42.0% to $71 million, NL Industries' 40.0% to $77 million, Kaiser Aluminum's 39.6% to $74 million, and Witco's 37.1% to $48 million.

Like the Top 50, there are different bases for reporting business segment data among the chemical companies on the Second 50 listing. Therefore, the data in the accompanying table should be viewed as approximate and the rankings taken only as a rough indication of the relative place in the chemical industry of any individual company. ☐

The U.S. chemical industry in 1981

U.S. chemical industry sales in 1981 kept up with inflation, but that is about all. Sales of all chemicals last year totaled about $142 billion, up 9% from the $132 billion sold by all sources the year before.

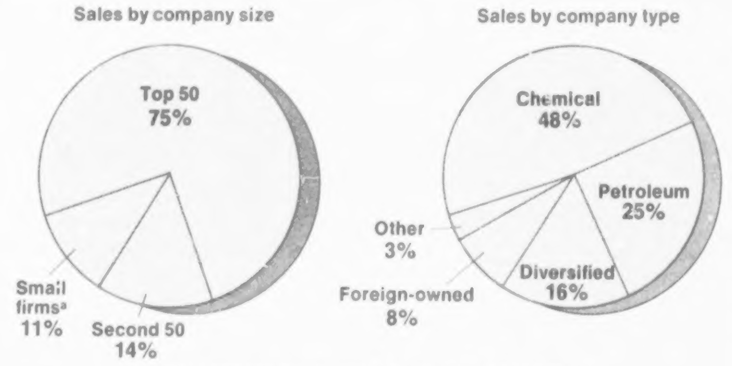
The companies selling these chemicals include not only those of C&EN's lists of Top 50 and Second 50 producers, but many other companies as well. These include companies that are too small to make the lists, and companies that do not disclose their chemical sales. This latter group includes many foreign-owned firms and some U.S. companies.

Of last year's chemical sales, the Top 50 chemical producers contributed $107 billion, or 75%. Sales by the Second 50 chemical producers totaled about $20 billion, or 14% of the total. The remaining $15 billion in sales came from small producers and chemical makers who do not disclose chemical data.

By company type, 48% of the sales came from chemical companies, 25% from petroleum and natural gas producers, 16% from other diversified companies, 8% from the U.S. operations of foreign firms, and the remaining 3% from firms that did not disclose chemical sales.

It is interesting to note that although diversified firms account for only 16% of the total chemical sales, they make up 29% of the firms on C&EN's two lists of producers, indicating that their chemical operations are rather small in comparison to other producers.

Meanwhile, the Commerce Department lists shipments of chemicals and allied products in 1981 at $182 billion. This, however, contains some products not included in C&EN's listing.



Total 1981 U.S. chemical sales = $142 billion

[a] Also includes firms not disclosing chemical sales.

Leaders among the Second 50 in profit, assets, and profitability

Rank		Operating profit ($ millions)		Operating profit margin[a]		Chemical assets ($ millions)		Return on chemical assets[b]
1	Freeport-McMoRan	$148	Big Three Industries	29.8%	Kerr-McGee	$685	Freeport-McMoRan	47.3%
2	International Flavors	102	Freeport-McMoRan	26.7	Merck	547	Vulcan Materials	30.1
3	Uniroyal	79	Vulcan Materials	23.7	Standard Oil (Ohio)	525	GAF	28.4
4	Big Three Industries	79	International Flavors	22.6	Big Three	505	International Flavors	27.2
5	NL Industries	77	Engelhard	19.6	Kaiser Aluminum	481	First Mississippi	27.0
6	Kaiser Aluminum	74	GAF	17.5	Pfizer	446	Petrolite	25.9
7	Merck	73	Petrolite	15.7	Pennwalt	436	Emhart	24.3
8	Pennwalt	73	Mississippi Chemical	15.4	Akzona	432	Engelhard	23.2
9	Cabot	66	First Mississippi	14.3	El Paso	425	Cabot	23.1
10	Beatrice Foods	63	Liquid Air	14.1	Uniroyal	415	NL Industries	21.5
11	Mississippi Chemical	61	Beatrice Foods	14.1	Badische	410	Witco Chemical	20.1
12	GAF	57	Emhart	14.0	Internorth	407	Uniroyal	19.0
13	Internorth	49	Kaiser Aluminum	13.9	Koppers	377	Pennwalt	16.7
14	Witco Chemical	48	Uniroyal	13.8	International Flavors	375	Tyler	16.0
15	Martin Marietta	48	NL Industries	13.6	NL Industries	358	Kaiser Aluminum	15.4

[a] Chemical operating profit as a percentage of chemical sales. [b] Chemical operating profit as a percentage of identifiable chemical assets.

Health, and the Environmental Chemicals Data & Information Network (ECDIN) of the Commission of the European Communities. Huismans' aim is to expand the number of such network partners even further.

Not surprisingly, IRPTC also maintains network ties with other bodies of the UN system, such as the Economic Commission for Europe, the Food & Agriculture Organization, the International Agency for Research on Cancer, the International Atomic Energy Agency, the International Labor Organization, and the World Health Organization. And close links have been established with the International Program on Chemical Safety formed two years ago by ILO, UNEP, and WHO.

A third source of information is the chemical industry itself as well as universities. "We see the industry as an excellent data source, provided we can sort out with them the data that are available," Huismans comments. "The chemical industry has an enormous store of undisclosed information of great value to us. Some of it is proprietary because it involves new product research. Some may reflect unfavorably on chemical safety. And much of it is unpublished because the chemicals have not shown adverse effects. Such data on safe use conditions of chemicals equally are of interest to IRPTC.

"We deal with producers on a company-by-company basis because their attitudes toward us differ. We work strictly on the understanding that we will not compromise on acceptability of data or tolerate any interference concerning what information goes into our data base. This doesn't mean that we expect companies to give us highly sensitive information such as manufacturing processes. But if we accept their data for our files, we expect the information to include everything that relates to health and environmental safety."

He admits to an attitude of distrust, sometimes even of hostility, toward the IRPTC concept on the part of industry in general, although he is quick to add that some companies do provide data on an ad hoc basis "if we ask the questions." But there are those in industry who question the need for IRPTC, noting that they, as producers of food additives, pesticides, or whatever, are in a much better position to advise on environmental effects, and, indeed, already have direct links with various government agencies on the safety of their products.

Responding to such an argument, Huismans points out that data in the register are compiled on the basis of strict scientific objectivity. Those who consult it can be confident that they are getting unbiased information. "We are geared to people in government or to those advising governments on chemical safety issues, as well as to all others with responsibility for chemical hazard control."

The 330 products in the register's initial list of chemicals span the alphabet from the 1,2-dihydro-5-nitro derivative of acenaphthylene, a dye intermediate and fungicide, to Ziram, a herbicide. Each entry carries an identifying Chemical Abstracts Service Registry number, or RTECS registry number, or both. Rather than merely providing bibliographic references, the register furnishes hard data—factual, numerical, and nonnumerical information, together with their sources.

Each entry will be updated frequently. Meanwhile, a further 100 or so chemicals will be added each year to the existing list.

All inputs are fed to a data bank at the UN's International Computing Center in Geneva. Ultimately, it will be possible for people to access the data bank and obtain a direct readout on computer terminals. Or the listings can be supplied on microfiche.

Currently, however, the information is going out as hard copy, since many who have use for it, especially if they are in less-developed countries, possess neither computer facilities nor microfiche equipment. The manual in its present form numbers at least 600 pages. ☐

U.S. chemical spending abroad to rise 27%

It would take brave managements to face stockholders and tout big new plant spending plans at annual meetings dotting the current calendar. After all, the surrounding business scene is clearly in recession, and plant use is the lowest in many years. But big new spending plans for chemical plants are definitely on corporate minds—in certain favored spots outside the U.S.

These foreign plant buildups are not just in the well-known regions with cheap raw material natural gas such as western Canada, Mexico, the Middle East, and Indonesia. They include some countries in Western Europe, Africa, and South America.

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of new data from the Commerce Department on foreign capital spending for various industries, including chemicals and allied products. After giving out overall foreign spending figures by industry a month ago, Commerce now goes into detail on the target countries.

Even the initial data were enough to raise eyebrows. For the chemical industry, Commerce found in a survey made last December that capital spending by majority-owned foreign affiliates of U.S. companies is expected to rise 27% in 1982 to $3.98 billion.

Such an increase is not at all in line with the state of plant and equipment funding showing up in other surveys, including C&EN's. Most other recent polls on the subject show a soggy investment outlook. For example, C&EN found that capital spending by leading basic chemical companies is planned to increase just 6% worldwide and 8% in the U.S. in 1982 (C&EN, Dec. 14, 1981, page 13). That's about in line with current construction inflation. In other words, project levels are flat.

Indeed, the Commerce survey shows that only one other industry, metals, plans a steeper gain in foreign capital spending in 1982 than does the chemical group. Even the oil industry, in an exploration binge, lags behind the chemical pace.

Why? Well, Commerce doesn't say. But one major difference between its survey and others is that it covers not just basic chemical companies but related firms in drugs, paints, cosmetics, and other areas. Also, Commerce's restricting the survey to foreign affiliates may introduce a skewing from the niceties of financing in the U.S. and abroad.

And in any case, these Commerce surveys have a history of overoptimism. For example, in the semiannual surveys for 1981 foreign chemical spending, Commerce first found last June that chemical and related companies planned a 19% increase from 1980. By December, the increase was scaled down all the way to 5%.

Recessionary reality can do the same thing this year too, although there are signs that business recovery is under way in foreign economies. The Conference Board, based in New York City, finds in its latest series of leading indicators for seven industrialized countries that recovery has started in the U.K., France, and Japan. The West German index is level, and weakness continues in Italy, Canada, and, of course, the U.S.

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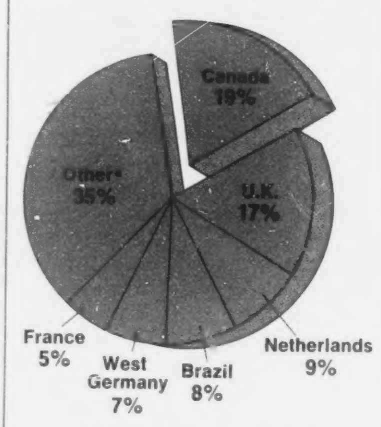
Canada gets biggest share of chemical foreign capital



1982 total = $3.98 billion

[a] Principal other countries are Spain 5%, Belgium 4%, Mexico 4%, Australia 3%, and Italy 3%.
Source: Department of Commerce

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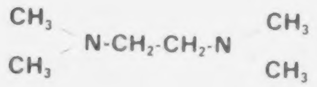

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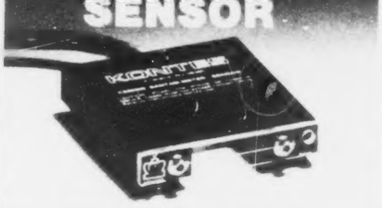

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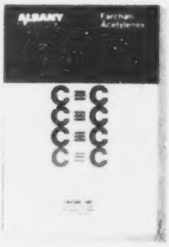

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expansion in mind, chemical and related companies are ticketing the biggest block of increased spending to such industrialized countries. Commerce finds that 79% of non-U.S. spending by these firms is heading for industrialized regions (53% to Western Europe) and just 21% to the developing world. Further, spending in the industrialized sector is due to rise 30%, whereas spending in developing areas is planned to rise just 19%.

A finer focus on the Commerce statistics shows an even choppier pattern in chemical spending plans. In both industrialized and developing worlds, only a few countries are slated for really large investment gains. Many others will idle or drop.

For example, in Western Europe, Commerce shows chemical spending gains going overwhelmingly to just three countries—two of them at the top of the list. Running away with number one spot is the U.K., with chemical spending due up 44% to $664 million. Second with an even larger 87% increase is the Netherlands, where 1982 spending is planned at $365 million. The only country in the world with more new chemical investment coming from the U.S. is Canada, where the western buildup is fueling a 19% jump this year to $775 million.

The third major investment target in Europe is Spain, where chemical spending is planned to increase 90% this year to $190 million. Other major percentage gains are 52% in Greece to $32 million and 40% in Sweden to $21 million.

Elsewhere in the industrialized sphere, two investment changes stand out. Chemical spending in Japan is forecast to fall 11% to $80 million. By contrast, investment in Australia is heading up 37% to $126 million.

In the developing world, a lopsided chemical investment slate throws two thirds of the total to just three countries. By far the largest is Brazil, with a 31% planned increase this year to $330 million. Next is booming Mexico, with a 16% chemical spending gain to $156 million. Third is Argentina, but here changed political conditions are driving planned chemical investment down 20% this year to $76 million.

Note that not one of these developing countries is in the Organization of Petroleum Exporting Countries. Commerce thoughtfully provides a separate total for OPEC countries. Perhaps surprisingly, chemical spending in OPEC is predicted to rise a relatively mild 11% in 1982 to $89 million. □

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Law of the Sea treaty goes ahead without U.S.
Page 20

Chemical & Engineering NEWS
May 17, 1982

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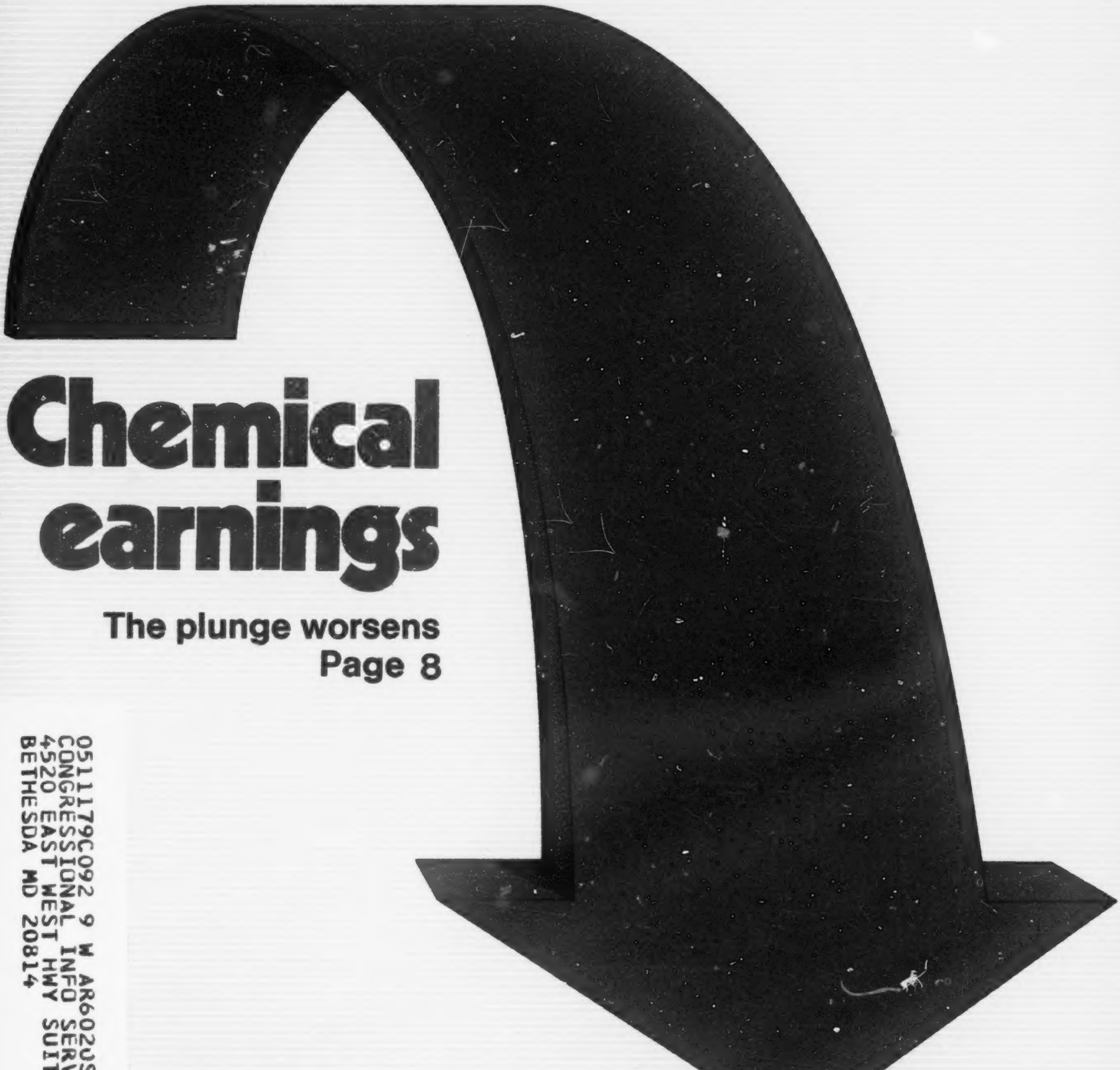

Chemical earnings

The plunge worsens
Page 8

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Chemical & Engineering NEWS

2 Letters

Concentrates
14 Business
19 Government
25 Science/Technology

The Departments
32 ACS Comment
35 Awards
36 People
44 Newscripts

News of the Week

- ***Chemical industry expectations*** *of an economic recovery have not materialized; second-half prospects are dim.* ***Page 4***
- ***The pattern of academic science*** *has been disrupted, NSF reports.* ***Page 5***
- ***Portable infrared device*** *for measuring trace amounts of PCBs developed by Battelle Columbus researchers.* ***Page 5***
- ***Political, scientific leaders*** *urge support for Soviet chemist's fast.* ***Page 5***
- ***Natural-gas-powered fuel cell*** *power plant undergoing field test.* ***Page 6***
- ***United Steelworkers boycotts*** *Procter & Gamble products claiming NTA detergent builder is a health hazard.* ***Page 6***

News Focus

- ***First-quarter combined profits*** *of 40 largest U.S. chemical firms plunged 33% from like period last year, sales 5.6%.* ***Page 8***

Business

- ***Robert W. Gerwig*** *of Conoco receives CMRA Memorial Award.* ***Page 15***

International

- ***Profits of major Canadian*** *chemical companies continue to decline.* ***Page 16***
- ***OECD report*** *predicts misuse of environment will constrain economic growth.* ***Page 17***
- ***Demand for carbon fibers*** *is expected to grow 35 to 40% annually during the next 10 years, especially for textiles.* ***Page 18***

Government

- ***UN's Law of the Sea treaty*** *may have little clout since U.S., other industrialized nations fail to support it.* ***Page 20***

Science

- ***Birth-control drug*** *that blocks pregnancy after fertilization by competing for hormone receptors developed in France.* ***Page 26***
- ***Study of Australian meteorite*** *reveals predominance of levo amino acids.* ***Page 27***

Education

- ***Rep. Don Fuqua,*** *chairman of House science committee, blames poor precollege teaching for technical manpower decline.* ***Page 28***
- ***Campus recruiting*** *for new chemical engineers is lessening.* ***Page 29***

Technology

- ***DOE chooses*** *atomic vapor laser isotope separation process for uranium enrichment for large-scale development.* ***Page 30***

ACS News

- ***ACS objectives for 1982*** *support long-range goals set in 1980.* ***Page 33***

Chemical earnings fall drastically

Combined profits at 40 largest basic chemical firms fell 33% in the first quarter on a sales decline of 5.6%; earnings at oil and diversified companies also plunged

William J. Storck, C&EN, New York, and William F. Fallwell, C&EN, Washington

Chemicals started 1982 not with a bang but with a bust. Chemical earnings were off across the board—at basic chemical companies, at oil companies with petrochemical operations, and at diversified companies that have large chemical businesses. It was a shellacking.

Thus, the drop in chemical earnings in the fourth quarter of 1981 (C&EN, Feb. 15, page 16) was only a prelude to an even greater drop in the first quarter this year.

Basic chemical companies (firms with more than 40% of their sales in chemicals and with chemicals making up the greatest portion of their sales) showed just how dismal business was in the first quarter.

Combined earnings at the 40 largest chemical companies declined 33.3% from the first quarter last year to about $958 million. And even sales fell—a rare event; for the 40 companies, they dropped 5.6% to $20.9 billion from the same period in 1981.

As a result, the combined profit margin for the group was 4.6% in the first quarter this year, down sharply from 6.5% in the first quarter last year.

These data are consistent for the two years, although the lineup of chemical companies has changed markedly this year. This year, for the first time, Du Pont is not on the list of basic chemical companies. After its acquisition of Conoco last year, its chemical operations weigh much less in the company total. Chemicals at Du Pont made up only 35% of sales in the first quarter as against 54% for petroleum and coal. Therefore, Du Pont has been transferred to the list of diversified chemical producers.

Diamond Shamrock also made the same switch because its chemical sales percentage has fallen. Mallinckrodt also is off the basic chemical companies list because it was acquired by Avon.

However, three new companies have joined the basic chemical list—FMC, National Distillers, and GAF.

There was once again something of a split this quarter in results of large basic chemical companies and those of smaller, more specialized firms. One might say that the larger firms performed slightly less poorly than the medium-sized companies.

Combined sales at the 20 larger basic companies dropped 5.7% to $18.6 billion in the first quarter. At the same time, combined earnings for this group dropped 32.6% to $853 million. Profit margins fell to 4.6% from 6.4% in the comparable period last year.

Among the 19 smaller basic companies that have reported thus far, the sales drop was not so bad: 4.5% to $2.29 billion. However, their earnings decline was worse: down 38.0% to $105.0 million.

As a result, profit margins among the more specialized firms also fell farther, enough so that their profitability is the same as the 20 big chemical producers. Profit margins for the smaller group dropped to 4.6% in the first quarter, compared to 7.1% in the first three months of 1981—a shocking change of fortunes for this usually favored group.

However, the drop in earnings was confined to a narrower group of companies within the smaller-sized firms. All 20 of the larger chemical companies had either earnings declines or deficits, whereas just 11 of the 19 smaller firms saw earnings give way.

Two of the hardest hit smaller firms are both minerals and fertilizer companies, reflecting the deepening woes in those industries. First Mississippi earnings declined 59% to $1.2 million in the quarter. And Freeport-McMoRan earnings dropped 42% to $26.5 million.

The deepening problems of the agricultural economy also had their

Chemical industry leaders for first-quarter 1982

Sales				Earnings[a]			Profitability		
Rank		$ Millions	Rank 1981		$ Millions	Rank 1981		Earnings as % of sales	Rank 1981
1	Dow Chemical	$2781.0	1	Monsanto	$147.5	3	Freeport-McMoRan	13.6%	1
2	Union Carbide	2312.1	2	Dow Chemical	97.0	1	Stauffer Chemical	13.0	3
3	Monsanto	1731.7	3	Union Carbide	90.8	2	Petrolite	10.3	6
4	Allied	1614.0	4	Stauffer Chemical	82.1	4	Nalco Chemical	9.7	4
5	W. R. Grace	1463.2	5	W. R. Grace	79.1	6	Great Lakes Chemical	9.4	2
6	Celanese	850.0	6	Allied	63.0	5	Chemed	8.7	10
7	American Cyanamid	845.5	7	American Cyanamid	38.0	9	Monsanto	8.5	7
8	FMC	844.6	8	FMC	32.5	12	Lubrizol	7.7	5
9	PPG Industries	752.2	9	Air Products	29.3	15	Liquid Air	7.5	9
10	B. F. Goodrich	728.6	10	National Distillers	28.4	16	Air Products	7.3	8

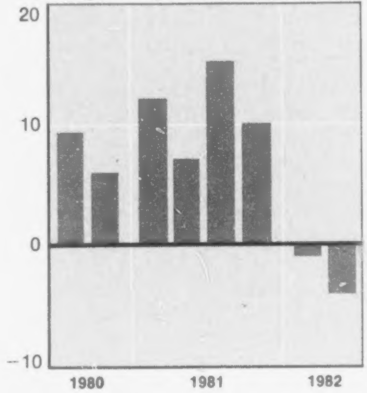
a After taxes. **Note:** For 40 chemical companies listed on page 10.

Chemical industry 1982 first-quarter results

- **Sales fell 4%**
- **Earnings plummeted 33%**
- **Profit margins sank**
- **Production declined 10%**
- **Prices rose 6%**

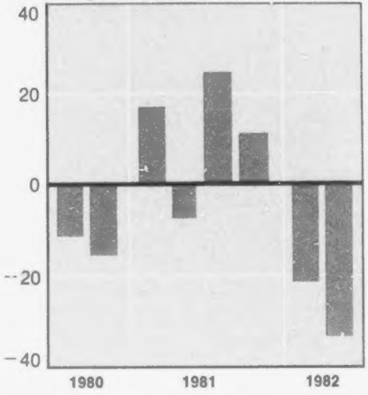
Sales

% change from year-earlier quarter



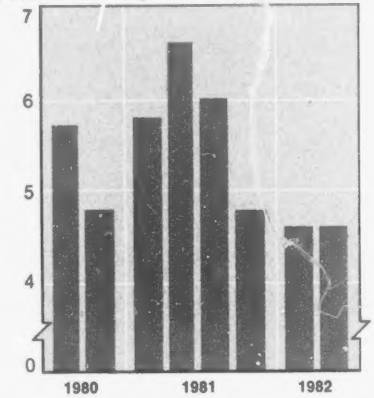
Earnings

% change from year-earlier quarter



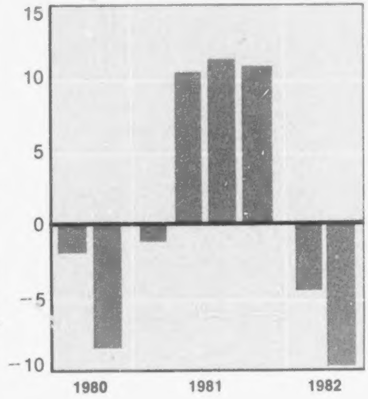
Profit margins

After-tax earnings as % of sales



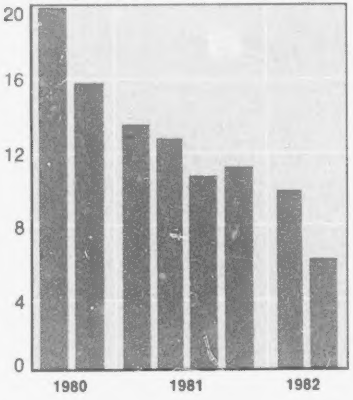
Production

% change from year-earlier quarter



Prices

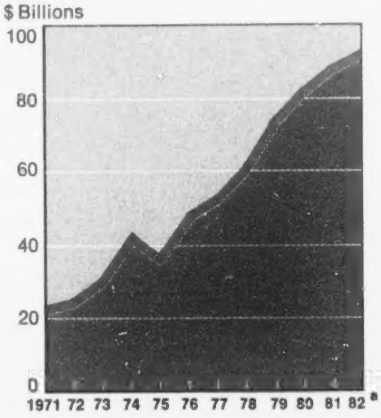
% change from year-earlier quarter



Sales in 1982 will rise about 5%, while earnings drop 15%, driving chemical profitability down to 4.6%

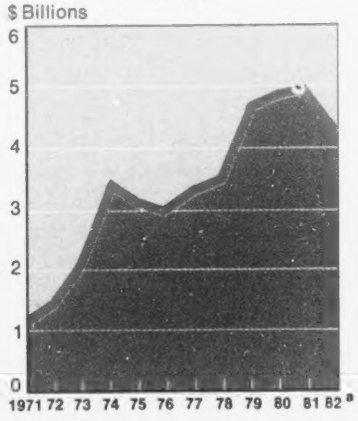
Annual sales

$ Billions



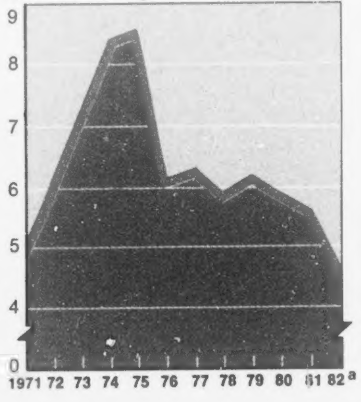
Annual earnings

$ Billions



Annual profit margins

After-tax earnings as % of sales



a C&EN estimates. **Note:** All sales, earnings, and profit margin data are based on the combined performance of the 40 largest chemical makers listed on page 10.

Earnings fell at all but eight chemical companies in first quarter

	FIRST-QUARTER 1982						12-MONTH RUNNING DATA			
	Sales	Earnings	Change from 1981		Profit margin[a]		Change from 1981		Profit margin[a]	
	($ millions)		Sales	Earnings	1982	1981	Sales	Earnings	1982	1981
Dow Chemical[d]	$ 2,781.0	$ 97.0	−4%	−46%	3.5%	6.2%	10%	−18%	4.5%	6.1%
Union Carbide	2,312.1	90.8	−12	−49	3.9	6.7	−2	0	6.2	6.0
Monsanto	1,731.7	147.5	−9	−16	8.5	9.3	2	31	5.1	4.0
Allied	1,614.0	63.0	2	−25	3.9	5.3	13	1	5.0	5.6
W. R. Grace[e]	1,463.2	79.1	−2	−5	5.4	5.6	4	7	5.0	4.8
Celanese	850.0	20.0	−7	−44	4.0	2.4	8	5	3.5	3.6
American Cyanamid	845.5	38.0	−5	−16	4.5	5.1	3	12	5.2	4.8
FMC	844.6	32.5	4	−22	3.8	5.1	6	18	4.9	4.4
PPG Industries[f]	752.2	16.5	−7	−70	2.2	6.8	4	−15	5.2	6.4
B. F. Goodrich[g]	728.6	−18.4	−7	def	def	1.2	1	39	2.2	1.6
Hercules	640.0	21.9	−4	−42	3.4	5.6	7	10	5.0	4.9
Stauffer Chemical	630.3	82.1	0	−7	13.0	14.0	−1	3	8.3	8.0
Olin	499.6	22.0	−4	−23	4.4	5.4	4	8	4.4	4.2
Rohm & Haas[h]	475.3	16.0	−1	−42	3.4	6.6	6	−9	4.5	5.3
National Distillers	464.4	28.4	−9	−16	5.3	6.7	2	30	6.6	5.2
International Minerals	419.2	23.5	−22	−44	5.6	7.9	−12	−27	6.7	8.1
Ethyl Corp.	402.7	17.1	−5	−19	4.2	5.0	0	−2	5.0	5.2
Air Products	399.1	29.3	−3	−21	7.3	8.9	4	1	7.7	7.9
Williams Cos.	393.9	5.9	−21	−89	1.5	10.4	−10	−62	3.1	7.2
Witco Chemical[i]	334.0	3.9	3	−34	1.2	1.8	7	1	2.8	3.0
Akzona	290.5	−2.7	−6	def	def	1.1	10	170	0.5	0.2
Pennwalt	246.7	5.3	−8	−46	2.1	3.7	−15	−13	3.4	3.3
Reichhold Chemicals	213.9	3.3	−11	−28	1.5	1.9	4	3	1.8	1.8
Thiokol	202.8	9.0	18	8	4.4	4.8	8	28	5.0	4.2
Lubrizol	201.8	15.6	−10	−35	7.7	10.8	−7	−13	10.4	11.0
Freeport-McMoRan	194.9	26.5	−13	−42	13.6	20.3	11	−11	16.9	21.1
Nalco Chemical	158.7	15.4	1	−20	9.7	12.2	7	3	11.6	12.0
GAF	139.5	−3.8	−21	def	def	1.8	−8	def	def	1.0
Liquid Air	103.5	7.8	−6	−17	7.5	8.6	3	−2	7.1	7.4
Petrolite	82.4	8.5	16	21	10.3	9.9	16	9	9.5	10.1
H. B. Fuller[j]	72.7	1.1	−7	−61	1.5	3.6	10	5	3.6	3.8
Chemed[k]	59.9	5.2	2	4	8.7	8.5	nc	nc	nc	nc
Loctite	54.8	3.3	−3	10	6.0	5.3	4	0	6.3	6.6
Crompton & Knowles	54.1	0.8	−10	−56	1.5	3.0	−1	−1	3.2	3.2
Stepan Chemical[i]	54.1	1.0	9	−17	1.8	2.4	24	47	3.0	2.6
First Mississippi	51.7	1.2	13	−59	2.3	6.3	7	14	7.3	6.8
Great Lakes Chemical	42.6	4.0	22	−26	9.4	15.2	24	−12	10.6	14.8
Essex	37.8	1.5	−5	60	4.0	2.3	8	54	5.2	3.6
Philip A. Hunt	30.1	2.0	15	91	6.6	4.0	9	def	2.9	def
International Flavors[m]	—	—	—	—	—	12.3	—	—	—	13.4
Total 20 largest companies	**$18,580.8**	**$852.9**	**−5.7%**	**−32.6%**	**4.6%**	**6.4%**	**4%**	**−2%**	**5.0%**	**5.3%**
Total 19 other companies	**$ 2,292.5**	**$105.0**	**−4.5%**	**−38.0%**	**4.6%**	**7.1%**	**3%**	**−9%**	**5.4%**	**6.1%**
GRAND TOTAL	**$20,873.3**	**$957.1**	**−5.6%**	**−33.3%**	**4.6%**	**6.5%**	**4%**	**−2%**	**5.1%**	**5.4%**

a After-tax income as a percentage of sales. **b** Fully diluted before nonrecurring items and extraordinary charges for operations. **c** As of April 30. **d** Excludes $57 million nonrecurring gain in first-quarter 1982. **e** Excludes $65.1 million nonrecurring gain in first-quarter 1982. **f** Excludes $7.6 million nonrecurring gain in first-quarter 1982. **g** Excludes $18.0 million extraordinary gain in first-quarter 1981. **h** Excludes $4.4 million nonrecurring gain in first-quarter 1981. **i** Excludes $3.1 million nonrecurring gain in first-quarter 1982. **j** Excludes $0.9 million extraordinary

effect on International Minerals & Chemical, which ranks as a larger producer. IMC had a 44% drop in earnings in the first quarter (third fiscal quarter) to $23.5 million. And IMC had one of the largest sales declines among the companies reporting, dropping 22% to $419 million.

Williams Cos., another large fertilizer producer, had the largest drop of any company on the list. Williams' earnings fell 89% to $5.9 million, and its sales dropped 21% to $394 million. As a result, its profit margin was almost wiped out, reduced to 1.5% from a lofty 10.4% in first-quarter 1981.

The basic chemical firms had plenty of company in the first-quarter profits storm. With a few lucky exceptions, some of them influenced by creative accounting, chemical producers of every stripe had a lot to complain about.

For oil companies, the ongoing woes of petrochemicals didn't stick out so much for once, matched this time by problems in much of the oil production chain. A combination of worldwide recession and falling oil prices left most oil companies not only with severe earnings drops but with sales declines, something the

STOCK MARKET DATA[c]

Earnings per share[b]		Stock price			Price-earnings ratio April 30	Annual indicated dividend	Dividend yield, % of price
			Recent 12 months				
1st qtr	Recent 12 months	April 30	High	Low			
$0.50	$2.80	$22¾	$36⅝	$20	9	$1.80	7.9%
1.32	8.24	47½	61¼	42⅜	6	3.40	7.2
3.71	8.68	66¼	87½	59½	6	4.00	6.0
1.38	8.08	34	59⅞	32	4	2.40	7.1
1.88	6.88	38¼	53	34⅜	6	2.60	6.8
1.21	7.39	58⅜	69¼	50¼	7	4.00	6.9
0.79	3.92	29⅛	36½	24⅜	7	1.75	6.0
0.90	4.63	27¼	34⅝	23⅛	7	1.60	5.9
0.49	5.26	34⅛	55¼	29	6	2.36	6.9
−1.18	2.62	20¼	27⅛	18½	6	1.56	7.7
0.50	3.06	21	26¼	17⅞	8	1.32	6.3
1.86	3.27	23	27	17¾	7	1.44	6.3
0.93	3.63	21⅝	27	18½	6	1.20	5.5
1.24	6.63	55¾	71¾	46¾	8	2.80	5.0
0.81	3.80	22½	29⅜	21⅛	6	2.20	9.8
0.69	4.49	31⅜	49	25¾	5	2.60	8.3
0.86	4.40	19½	33	18⅛	4	1.50	7.7
1.03	3.17	35¼	46	31	8	0.80	2.3
0.20	2.14	20	35⅜	18	9	1.20	6.0
0.72	4.22	23⅜	31½	21⅛	6	1.80	7.7
−0.22	0.51	9¾	15¼	9¼	21	0.80	8.2
0.52	3.33	26½	32½	23⅝	6	2.20	8.3
0.38	1.95	12⅜	15¾	10	7	0.48	3.9
0.77	3.24	35⅝	39	26½	11	1.10	3.1
0.40	2.14	21⅜	31⅝	17⅛	10	1.08	5.1
0.38	2.02	16⅜	39⅜	15⅛	8	0.60	3.7
0.77	3.86	45½	58¼	41	11	2.24	4.9
−0.32	−2.04	13	16⅜	8⅝	—	0.80	6.2
0.64	2.62	18	27½	16¼	7	1.60	8.9
0.72	2.46	29¾	43¼	24¾	12	1.00	3.4
0.23	2.58	14½	26½	14¼	6	0.52	3.6
0.31	1.20	21½	25⅛	16⅞	18	1.25	5.8
0.33	1.39	23	28	18⅛	17	0.56	2.4
0.20	2.18	13⅞	18¾	13½	6	1.04	7.5
0.27	1.71	12⅜	21⅜	11½	7	0.56	4.5
0.06	1.15	9½	23⅜	8⅞	8	0.24	2.5
0.55	2.31	30⅞	58½	27⅞	13	0.52	1.7
0.52	2.76	20	20¼	14¾	7	0.80	4.0
0.35	0.99	10⅛	11¼	8⅜	12	0.40	4.0
—	—	18¾	22⅜	17⅜	10	1.00	5.3

gain in first-quarter 1982. **k** Chemed has restructured and some historical data are not yet restated to be comparable. Earnings per share are estimated. **l** Excludes $0.7 million nonrecurring charge in first-quarter 1981. **m** Not all information available at press time. **nc** = not comparable; **def** = deficit.

energy world hasn't seen in at least a decade. Exceptions were firms like Standard Oil (Ind.), which could take advantage of cheaper oil in its refineries. Two other big gas sellers, El Paso and Internorth, also would have had profits increases, but any potential gains were smothered by the rugged market influence from petrochemicals and natural gas liquids.

Among the more diversified chemical producers, chemical profit centers got some of the worst notices in first-quarter reports. For example, Borden's chairman, Eugene J. Sullivan, laid a "sharp drop" in chemical division income to "near-catastrophic" conditions in housing and auto markets and to higher natural gas costs. Upjohn's chemical areas operated at a loss with a 24% drop in sales. Esmark had a near disappear-

Ground rules for the C&EN earnings analysis

C&EN's quarterly report on financial performance of the U.S. chemical industry contains data from the 40 largest U.S. basic chemical companies and from 50 diversified companies, each with more than $200 million in annual chemical sales.

The 40 largest chemical firms included in the table on pages 10 and 11 produce 50 to 60% of chemicals sold in the U.S. To be included in this table a company must have at least 40% of its sales in chemicals, and its chemical operations must be the largest single portion of the company's operations. The table of nonchemical firms on pages 12 and 13 is divided into two groups: oil and gas companies specializing in basic petrochemicals, and major diversified firms with large chemical operations. In both cases, chemical sales are more than $200 million annually.

Also included is a state-of-the-industry page. These graphs give quarterly comparisons for the past two years on five specific measures for the 40 largest chemical firms, plus annual data for the past decade for the same group.

In referring to chemical sales, C&EN means those chemicals whose molecular composition has been changed in the course of manufacture. Hence, chemical sales include those of traditional categories of basic petrochemicals and inorganics, organic intermediates and inorganic compounds, polymers such as plastics and fibers, agricultural chemicals, and specialty derivatives. The list does not include companies whose primary business is formulating or fabricating products made from purchased process chemicals. By the government's Standard Industrial Classification code, the survey's chemicals would fall into SIC categories 281, 282, 286, 287, and, in part, 289.

In listing earnings, the survey gives after-tax income for continuing operations before nonrecurring items and extraordinary charges. Foreign currency translations are included. Earnings per share are given with full dilution.

In other definitions, profit margin is after-tax earnings as a percentage of net sales. The 12-month indicated dividend is the latest announced quarterly dividend multiplied by four with year-enders.

Twelve-month earnings per share are for the year ending with the latest quarter. Yield is the indicated annual dividend as a percentage of latest stock price. Shares outstanding are generally averages for the latest quarter.

Sales slip and earnings plummet at many diversified chemical producers

	Chemical sales as % of total sales	FIRST-QUARTER 1982						STOCK MARKET DATA			
		Total sales ($ millions)	Earnings ($ millions)	Change from 1981		Profit margin[a]		Earnings per share		Stock price	
				Sales	Earnings	1982	1981	1st qtr	Recent 12 months	April 30	12-Month high
OIL AND GAS COMPANIES											
Exxon	7%	$27,109.0	$1240.0	−11%	−23%	4.6%	5.3%	$1.43	$6.01	$28¼	$36
Mobil	3	16,439.0	326.0	−4	−49	2.0	3.7	0.77	4.99	21¾	32
Texaco	3	13,000.0	367.0	−16	−44	2.8	4.3	1.41	7.71	29½	39½
Standard Oil of California	3	10,020.0	230.0	−16	−65	2.3	5.6	0.67	5.68	29⅞	46
Gulf Oil	8	7,538.0	267.0	−4	−12	3.5	3.8	1.44	6.26	30⅞	41⅜
Standard Oil (Ind.)	10	7,200.0	470.0	−9	25	6.5	4.8	1.60	6.60	42	64⅛
Atlantic Richfield	8	6,427.2	385.4	−10	5	6.0	5.2	1.53	6.72	39⅛	54⅛
Shell Oil	16	4,842.0	345.0	−11	−4	7.1	6.7	1.12	5.46	35⅜	49¼
Occidental Petroleum[b]	16	4,211.7	62.1	25	−76	1.5	7.6	0.41	4.96	19⅜	31¼
Sun Co.	5	3,900.0	124.0	−2	3	3.2	3.0	1.01	5.19	34½	48¾
Tenneco	10	3,844.0	129.0	1	−34	3.4	5.1	0.88	5.38	26⅞	43⅝
Phillips Petroleum	15	3,813.0	189.0	−10	−30	5.0	6.4	1.24	5.24	31½	47⅛
Getty Oil	2	3,124.6	163.9	−5	−29	5.2	7.0	2.01	9.63	49¾	79¾
Standard Oil (Ohio)	3	3,055.6	454.7	−4	−13	14.9	16.3	1.85	7.65	34⅝	54⅛
Union Oil	11	2,481.6	168.5	−7	9	6.8	5.8	0.97	4.50	33¾	45⅝
Cities Service	3	2,277.4	53.3	4	−19	2.4	3.0	0.68	3.39	32¾	30⅝
Internorth	10	1,452.8	106.6	27	−9	7.3	10.2	2.40	5.22	27¼	36¼
Kerr-McGee[c]	14	936.7	46.2	2	7	4.9	4.7	0.89	4.12	30¾	43¾
El Paso	15	934.0	21.2	3	−31	2.3	3.4	0.44	2.86	23⅜	28⅛
American Petrofina	13	575.2	16.0	−14	−21	2.8	3.0	1.48	6.48	62½	63¼
DIVERSIFIED MANUFACTURERS											
Du Pont	35	8,289.0	250.0	2	−20	3.0	3.9	1.06	5.55	35⅜	56
General Electric	4	6,020.0	377.0	−1	5	6.3	5.9	1.66	7.35	64⅛	69⅞
U.S. Steel[b]	10	5,002.7	79.9	47	−71	1.6	8.0	0.86	5.11	24⅝	34⅞
Procter & Gamble	4	3,094.0	198.0	5	15	6.4	5.8	2.39	9.14	85⅜	87⅝
Dart & Kraft	11	2,439.4	96.9	2	−6	4.0	4.3	1.77	7.33	51⅞	54¾
Eastman Kodak	23	2,247.6	181.3	−3	−27	8.1	10.8	1.12	7.24	71	82¾
Beatrice Foods	5	2,227.6	74.0	0	5	3.3	3.2	0.68	2.87	19⅜	23½
Goodyear Tire	12	2,147.3	45.6	−3	−20	2.1	2.6	0.63	3.21	23⅛	23⅝
3M	15	1,666.0	152.4	5	−10	9.1	10.7	1.30	5.60	54⅞	63¾
Aluminum Co. of America[c]	11	1,212.8	23.9	−8	−76	2.0	7.7	0.31	2.74	25	36
Georgia-Pacific[c]	14	1,199.0	25.0	−11	−52	2.1	3.9	0.23	1.23	16½	30⅝
Borden[c]	32	928.3	17.2	−12	−47	1.9	3.1	0.57	4.72	33¼	34¼
Eli Lilly	18	863.2	135.6	6	9	15.7	15.3	1.78	5.07	62¾	68½
Pfizer	13	808.4	88.2	0	18	10.9	9.2	1.14	3.77	55⅞	59¼
Northwest Industries	6	794.4	94.6	13	94	11.9	6.9	4.10	11.04	66⅞	80½
Diamond Shamrock	34	791.1	29.1	−9	−52	3.7	7.0	0.47	3.18	21½	39⅝
Martin Marietta	14	748.5	15.8	4	−60	2.1	5.5	0.44	4.77	29⅛	51⅛
Merck	23	743.6	109.8	3	−2	14.8	15.4	1.48	5.34	76½	103
Kaiser Aluminum	17	733.8	−24.9	−12	def	def	8.2	−0.56	0.90	12⅝	26¼
Esmark	18	725.2	13.5	7	10	1.9	1.8	1.01	7.63	45⅝	55½
NL Industries	23	665.2	93.5	25	61	14.0	10.9	1.39	5.14	24⅞	48⅝
Borg-Warner	24	635.4	36.3	−6	5	5.7	5.1	0.85	4.05	28½	28⅞
Uniroyal[c]	25	485.1	1.2	−10	−90	0.2	2.1	0.04	1.33	7⅞	10⅜
Upjohn	17	460.2	42.9	−4	−24	9.3	11.8	1.42	5.57	46½	67¾
General Tire[c]	19	456.6	−3.8	−8	def	def	0.6	−0.15	2.71	18½	29½

a After-tax income as percentage of sales. b Earnings include nonrecurring items. c Excludes major nonrecurring items: Kerr-McGee—$17 million charge first-quarter 1982; Aluminum Co. of America—$19.9 million in first-quarter 1982; Georgia-Pacific—$135 million in first-quarter 1982; Borden—$17.6 million in first-quarter 1982; Uniroyal—$18.0 million in first-quarter 1982; General Tire—$30.8 million charge in first-quarter 1982 and $4.4 million charge in first-quarter 1981.

STOCK MARKET DATA

Stock price 12-Month low	Price-earnings ratio April 30	Annual Indicated dividend April 30	Dividend yield % of price
$27\frac{3}{8}$	5	$3.00	10.6%
$20\frac{3}{4}$	4	2.00	9.2
$29\frac{1}{4}$	4	3.00	10.2
$28\frac{3}{4}$	5	2.40	8.0
$27\frac{3}{4}$	5	2.80	9.1
$34\frac{1}{8}$	6	2.80	6.7
$33\frac{1}{4}$	6	2.40	6.1
$27\frac{1}{8}$	6	1.80	5.1
$18\frac{5}{8}$	4	2.50	12.9
29	7	2.30	6.7
$24\frac{7}{8}$	5	2.60	9.7
27	6	2.20	7.0
$41\frac{1}{4}$	5	2.40	4.8
$29\frac{1}{8}$	5	2.60	7.5
$27\frac{1}{8}$	7	1.00	3.0
$20\frac{1}{4}$	10	1.60	4.9
24	5	2.12	7.8
$26\frac{3}{4}$	7	1.10	3.6
$20\frac{1}{4}$	8	1.48	6.3
$41\frac{1}{2}$	10	3.20	5.1
31	6	2.40	6.8
$51\frac{1}{8}$	9	3.20	5.0
22	5	2.00	8.1
$67\frac{3}{8}$	9	4.20	4.9
$44\frac{5}{8}$	7	3.60	6.9
$60\frac{5}{8}$	10	3.00	4.2
$16\frac{3}{4}$	7	1.50	7.7
$15\frac{7}{8}$	7	1.40	6.1
48	10	3.20	5.8
$21\frac{7}{8}$	9	1.80	7.2
$15\frac{3}{8}$	13	1.20	7.3
$26\frac{1}{4}$	7	2.22	6.7
$45\frac{1}{4}$	12	2.60	4.1
40	15	1.84	3.3
$43\frac{3}{4}$	6	2.68	4.0
$19\frac{1}{2}$	7	1.76	8.2
$26\frac{1}{8}$	6	1.92	6.6
$70\frac{3}{8}$	14	2.80	3.7
12	14	0.60	4.8
$30\frac{3}{8}$	6	1.84	4.0
$21\frac{1}{8}$	5	1.00	4.0
$21\frac{1}{8}$	7	1.40	4.9
$5\frac{7}{8}$	6	0	0
$42\frac{1}{8}$	8	2.28	4.9
$18\frac{3}{8}$	7	1.50	8.1

ance of operating profits in Estech, its chemicals segment. At Diamond Shamrock, chairman William H. Bricker reports both a physical volume and profit margin decline in chemicals. Especially hard hit were industrial and electrolytic (chlor-alkali) chemicals. Diamond's more specialized chemicals did better.

Amid such widespread gloom, it's worth recording the few brighter notes. For instance, NL Industries, which can't seem to join the recession, had a 13% gain in chemical operating profits in the first quarter from a year earlier. NL's overall eye-popping profits gains came from its oil-field business, the same source as similar gains at Northwest Industries.

And at beleaguered Georgia-Pacific, the forest products giant, there's even a good word for chemicals. Says chairman Robert E. Flowerree, "We noticed a good pickup in polyvinyl chloride resin sales in March after a long period of softness. This followed a similar increase for thermosetting resins that started in February, which was helped by new industrial lines we acquired last year."

Is Georgia-Pacific onto something? Most companies think not, at least for the second quarter. Du Pont chairman Edward G. Jefferson already has said that the second quarter looks even more difficult than the first (C&EN, May 10, page 11).

Eastman Kodak chairman Walter A. Fallon has a similar comment: "Many of the pressures that caused the first-quarter earnings decline are still at work." But Fallon foresees a consumer-driven economic recovery under way by the fourth quarter, leading to a "very positive" start for 1983.

Cautious hopes for the second half of 1982 also are the message from General Electric. Chairman John F. Welch Jr., an old chemical hand, says, "The remainder of 1982 will continue to be challenging. We anticipate very little economic improvement in the second quarter. Our economists are looking for a moderate recovery in the third and fourth quarters fueled by the July tax cut and lower inflation."

For the basic chemical industry, another sandbagging of profits in the second quarter would dash all thought of profits recovery for the year. The hopeful view now looks like a profits drop of 15% for the year on a slim 5% sales increase. Profit margins will continue to suffer, dropping to less than 5% for the first time in recent decades. □

Petrochemical earnings deepen the trough

The sad state of petrochemicals hardly needs belaboring. Their profits collapse has been going on without a break since second-quarter 1980. Only once, in third-quarter 1981, did petrochemicals nearly match their previous year's performance.

The dismal data for first-quarter 1982 show little break in the pattern, except that low raw material prices finally began to benefit producers like Shell Oil buying large lots on the outside. For most, however, the effect of the monstrous price discounts and idled plant capacity this winter has been terrible.

For five of the largest chemical-producing oil companies giving after-tax data on chemicals, the combined profits drop in the first quarter was another 38%. This follows a 50% tumble in last year's first quarter. In other words, petrochemical earnings now are down about 70% from their last good quarter at the start of 1980.

A few more specific figures from companies show how bad the business drop has been. At number-one petrochemical producer Exxon, chairman Clifton C. Garvin Jr. says that chemicals had a physical sales volume drop of 23% in the U.S. and 13% abroad from a year earlier. That's a shocking loss of product flow. It was even worse in some chemical areas at Atlantic Richfield, which reports a sales poundage drop of 34% in aromatics, 55% in olefins, and 23% in polymers in the first quarter.

Translating this volume drop into dollars, companies have come up with a lot less sales and profits than a year ago and show traces of red ink. For example, Mobil's merchant chemical sales fell 8% in the first-quarter from first-quarter 1981, and Exxon's chemical product revenue (including transfers to its petroleum affiliates) fell 17%.

In short, petrochemicals remain in the grip of a tremendous recession, much worse than for the chemical industry as a whole. Unfortunately, there is no relief in sight.

$ Millions	First-quarter after-tax earnings 1982	1981	% change
Exxon	$31.0	$ 61.0	−49%
Mobil	13.0	26.0	−50
Shell Oil	10.0	6.0	67
Standard Oil (Ind.)	27.0	39.0	−31
Texaco	15.0	22.0	−34
TOTAL	**$96.0**	**$154.0**	**−38%**

Canadian chemicals slump deepens

Profits of Canada's leading chemical firms continued their decline through first quarter, plunging 87%; sales were down 7.6%

First-quarter results from some of the early-reporting Canadian chemical companies confirm the industry's pessimism about the first half of 1982. Business has gone from bad to worse.

The slump that became so evident in the second half of 1981, particularly in the fourth quarter, became even more severe in the first three months of 1982.

Based on the combined results of the four largest publicly reporting Canadian chemical companies (C-I-L Inc., Celanese Canada, Du Pont Canada, and Union Carbide Canada), profits have been deteriorating for six consecutive quarters through the end of last year. In the fourth quarter of 1981, profits slipped 63.6%, compared to the same period of 1980.

Then, in the first quarter of 1982, profits of the Big Four dropped again. This time, the decline was a staggering 87.2%.

And this time, there was another notable difference. Although profits had dropped in the past several quarters, they were at least based on increased sales. In this year's first quarter, however, combined sales of the Big Four dropped too. And there's little reason to believe the rest of the Canadian chemical industry fared any better.

The combined sales of the Big Four in the first quarter were $793 million (Canadian), down 7.6% from first-quarter 1981. This, coupled with a combined net income of only $6 million, gave the four companies a slender profit margin of 0.7%. That's only a whisper of what they enjoyed in the first quarter of 1981, when their average profit margin was 5.4%. This alone is enough to give Canadian chemical executives sleepless nights. But there is little hope for a quick improvement. Many Canadian economists are revising earlier projections of an upturn in the Canadian economy early in the second half. They now are looking for a U.S. economic recovery during the second half, with a Canadian recovery lagging behind by three to six months.

Canadian chemical leaders apparently agree. Du Pont Canada president J. Edward Newall says, "It now appears likely that no meaningful recovery in business activity will take place before the fall at the earliest." As a result, he expects his company's 1982 earnings to fall well short of their 1981 levels.

W. Norman Kissick, president of Union Carbide Canada, echoes these sentiments. He is "cautiously optimistic" that signs of real economic recovery in the U.S. will begin to appear by the third quarter and that a turnaround in Canadian business will follow.

The reasons behind the dilemma are, of course, not new. They have been around for some time and boil down to a classic cost-price squeeze. Rapidly rising raw material costs, particularly for petrochemicals as a result of the country's controversial energy policies, are putting the squeeze on one end. Recessionary markets, at home and in the international marketplace, are leading to price deterioration and are putting the squeeze on the other end.

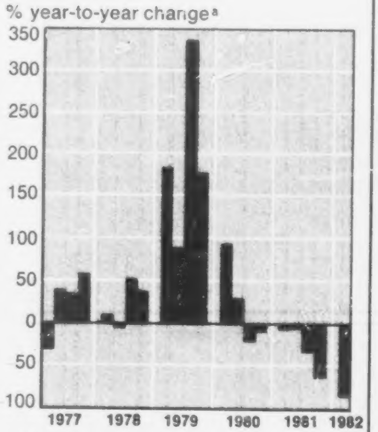
Hardest hit as a result are those companies heavily involved in fibers, plastics, and petrochemicals. At Union Carbide Canada, for instance, although the impact was felt in its downstream consumer and related businesses, the most profound jolt came in the company's plastics and chemical segments.

Du Pont suffered a first-quarter loss on operations of $1.2 million. But at the end of the quarter, it also absorbed an extraordinary after-tax charge of $6.8 million as a result of its plans to shut down its cellulose film plant at Shawinigan, Que. The plant will close July 30.

The only one of the Big Four that pushed sales upward in the first quarter was C-I-L Inc. Sales increased 5.4% to $285 million, primarily because its product line is more diverse than the others. The gains came mostly in explosives, industrial chemicals, fertilizers, and plant-protection products.

Earl Anderson, New York

Combined earnings: worst drop yet



[a] After-tax earnings of four largest publicly reporting Canadian chemical companies—Celanese Canada, C-I-L, Du Pont Canada, and Union Carbide Canada.

Canadian chemical sales and earnings take a beating

	First-quarter 1982					
$ Millions (Canadian)	Net sales	Change from 1981	Net income	Change from 1981	Profit margin[a] 1982	Profit margin[a] 1981
C-I-L Inc.	$285.2	5.4%	$6.1	−45.0%	2.1%	4.1%
Celanese Canada	79.0	−24.6	0.9	−85.8	1.1	5.9
Du Pont Canada	247.3	−12.6	−1.2[b]	−108.2	−0.5	5.2
Union Carbide Canada	181.7	−9.2	0.2	−98.6	0.1	7.3
TOTAL	$793.2	−7.6%	$6.0	−87.2%	0.7%	5.4%

[a] Net income as percentage of sales. [b] Loss on operations only. An extraordinary charge of $6.8 million (Canadian), representing cost of impending shutdown of a cellulose plant, brings total first-quarter loss to $8.0 million (Canadian).

Major growth ahead for carbon fibers

Against the background of the currently depressed state of world economies and mediocre demand for fibers, the prospect of a 35 to 40% annual growth for a man-made fiber is startling, to say the least. Yet that appears to be the short-term prospect for graphitic, or carbon, fibers.

The prediction comes from David S. Buck, textiles analyst at Laing & Cruickshank, a firm of stockbrokers based in London. "We believe the time has been reached when innovation is passing out of its early evolutionary growth into its major five- to 10-year commercial growth period when maximum profits are earned," Buck surmises.

Others, presumably, share his view as evidenced by the recent spate of decisions to go ahead with installation of new capacity. For instance, Hercules, the largest U.S. producer of carbon fibers, has teamed up with Pêchiney-Ugine-Kuhlmann of France to build a plant near Grenoble. The new company, Société Européen de Fibres et Composites, will be capable of producing 450,000 lb annually when its $12 million unit is completed toward the end of 1983.

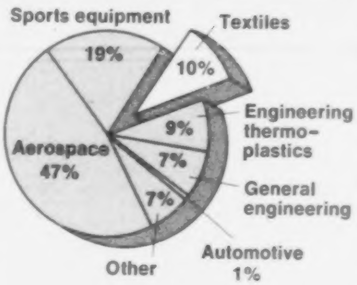
In the U.S. Celanese has started up a 300,000 lb-per-year carbon fiber plant, the company's first entry into production. The new plant is at the company's Celriver plant in Rock Hill, S.C.

And Union Carbide, the U.S. leader in high-performance carbon fibers, has made a number of recent moves. It has completed a plant at Greenville, S.C., to produce high-modulus carbon fiber from petroleum pitch. The plant, the first commercial application of this technology, has an annual capacity of 500,000 lb (C&EN, April 5, page 18). The company is starting up another 1 million lb-per-year carbon fiber plant at Greenville that uses the conventional polyacrylonitrile feedstock.

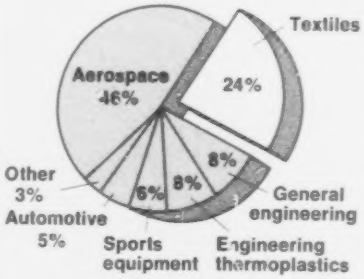
Carbide has canceled out of a planned joint venture with Toray Industries of Japan and Société Nationale Elf Aquitaine of France to make carbon fibers in France.

There are some, however, who voice concern that carbon fiber capacity might be going the way of the other man-made fibers, and that the danger of overcapacity looms large. Such reasoning may have been a factor in the decision of Elf Aquitaine, Toray, and Union Carbide to cancel plans for a three-way partnership that would have made the product, also in France.

Textiles will be fastest growing graphite fibers use



Total 1981, worldwide = 2.9 million lb



Total 1986, worldwide = 14.3 million lb

Source: Laing & Cruickshank

Consumption of graphite fibers to continue to expand

Thousands of lb	1979	1980	1981	1986	Annual change 1979–81	Annual change 1981–86
U.S.	660	1276	1958	8580	72.2%	34.4%
Japan, Western Europe	594	792	968	5720	27.7	42.7
TOTAL	1254	2068	2926	14,300	52.8%	37.3%

Source: Laing & Cruickshank

Indeed, Courtaulds, the U.K.'s leading carbon fiber maker and an early developer of the material, last week voiced concern about the Hercules-PUK French venture, citing the fact that the new plant's initial capacity will be considerably greater than the 300,000-lb or so annual French domestic demand. At the same time, Courtaulds is increasing capacity of its operation in Coventry, England, from the present 440,000 lb-a-year level to 572,000 lb by year's end.

Carbon fibers still are regarded as specialties. As such, they command a high price, up to $30 per lb and higher, depending on grade, type, and volume sold. But tabs have come down. Price to the consumer has been cut more than half during the past 10 years. The steepest downturn, between 20 and 30%, occurred in the past five years, despite inflation and rising energy costs, and Buck foresees a further halving in the coming five years as use expands.

The first step in production of carbon fiber involves oxidation of a special acrylic fiber. Other precursors, such as rayon or pitch, may be used. Next follows a carbonization step in which the oxidized fiber is heated to between 1000 and 1500 °C in an inert atmosphere.

Composites made from carbon fibers are much lighter than metals without sacrificing strength or stiffness. Consequently, they result in considerable weight saving, an important element in the aerospace and aircraft industry, and, to an increasing extent, in automobiles.

"The field of electrical thermoplastics is likely to develop into a sizable market, because the conductive properties of carbon fiber composites can be used for electrostatic dissipation," Buck notes. "Meanwhile, development is proceeding rapidly in the area of flameproof textile products, and development of nuclear, biological, and chemical protective suits is a high military priority."

The U.S. is the biggest market for carbon fibers. Consumption last year was about two thirds of the noncommunist world total of nearly 3 million lb. Buck believes that this position will be maintained in the years immediately ahead, and that U.S. use will account for 60% of the world total in 1986, which, by then, probably will exceed 14 billion lb. However, the annual growth rate of sales in Japan and Western Europe combined (43%) will be greater between 1981 and 1986 than for the U.S. (34%). □

Chemical plant capacity
use hits new low
Page 16

Chemical & Engineering NEWS

May 24, 1982

5/25/82

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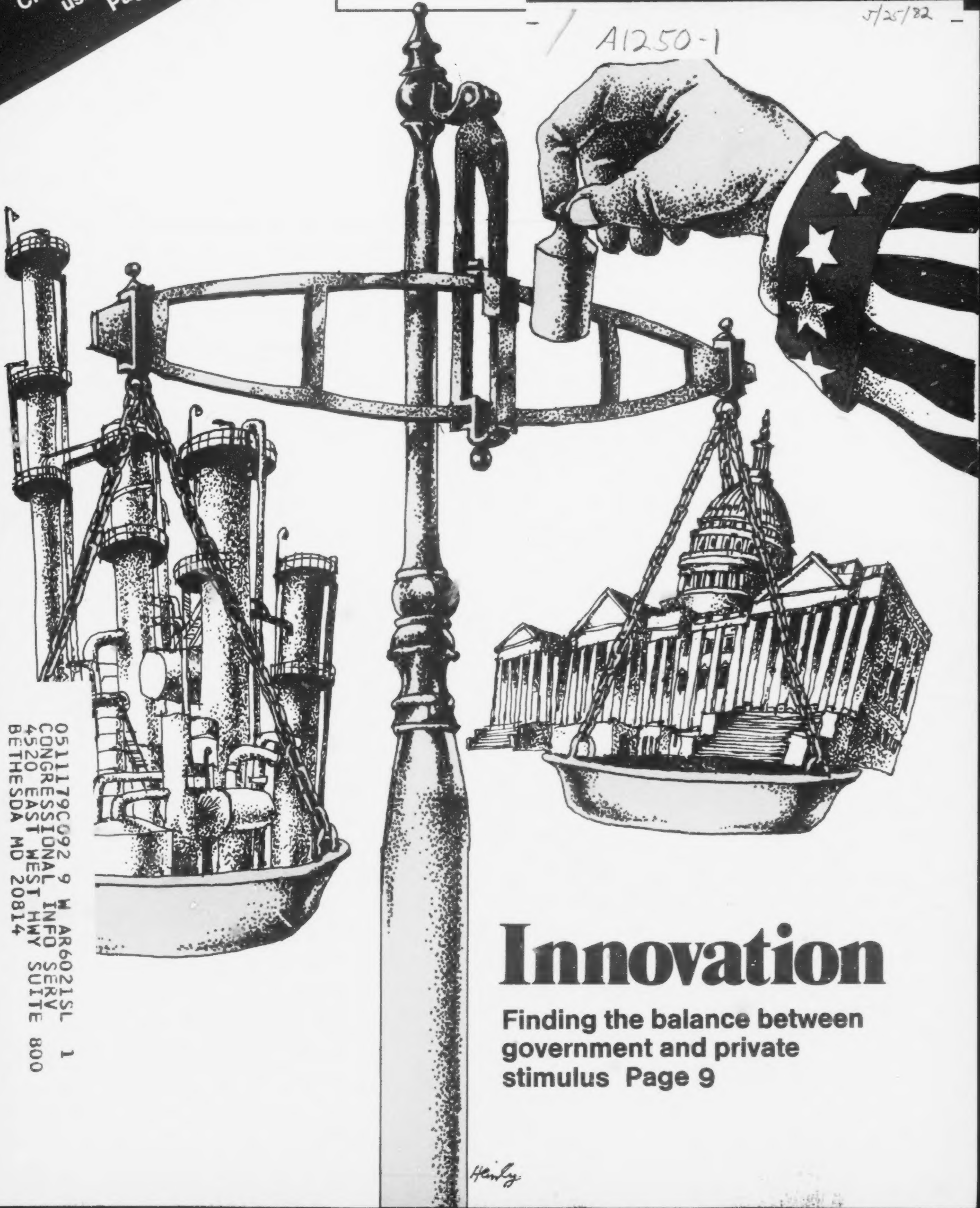

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Innovation

Finding the balance between
government and private
stimulus Page 9

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Chemical & Engineering NEWS

4 Letters

Concentrates

15 Business
24 Government
33 Science/Technology

The Departments

60 Newscripts

News of the Week

- ***Kuwaiti interests*** *have purchased 25% of Hoechst, rumors go.* ***Page 6***
- ***Professional societies held liable*** *for standards set by members.* ***Page 7***
- ***Chemical industry will boost*** *pollution-control spending 10% in 1982.* ***Page 7***
- ***Neighbors of Three Mile Island vote no*** *to restarting nuclear reactor.* ***Page 8***
- ***U.S. output of aerosols*** *rose 1.5% in 1981 over 1980 production.* ***Page 8***
- ***Dow Chemical petitions EPA*** *for exemption for monochlorinated biphenyls.* ***Page 8***

News Focus

- ***Innovation in U.S.*** *may be spurred by better balance between private and government involvement.* ***Page 9***

Business

- ***U.S. chemical capacity use*** *goes down to 60%.* ***Page 16***
- ***Pickup in polypropylene business*** *is only bright spot for olefins makers.* ***Page 19***
- ***Weaker sulfur markets*** *predicted for next two years.* ***Page 20***

International

- ***U.S. chemical exports*** *face stiff competition from foreign world-scale plants.* ***Page 21***
- ***Chemical needs of South American*** *markets are changing constantly.* ***Page 22***

Government

- ***House Agriculture Committee*** *approves changes in pesticide regulation.* ***Page 25***

Science

- ***Stability of six-nitrogen ring debated;*** *scientists study possibility of synthesis at low temperature.* ***Page 36***

Gibbs Medal

- ***Gilbert Stork*** *of Columbia University receives Willard Gibbs Medal.* ***Page 37***

Education

- ***NAS conference on precollege education*** *in science and math spots problems, disagrees on federal participation.* ***Page 39***

Books

- ***Life in space?*** *Author and reviewer think so, but differ as to what kind.* ***Page 42***

ACS News

- ***Latest CPR report on layoffs*** *proves older chemists are not immune.* ***Page 44***
- ***Official reports*** *of Las Vegas meeting include committee doings.* ***Page 45***

Voters reject reopening undamaged TMI plant

True it was a nonbinding referendum, but it was overwhelming. By a vote of more than two to one, Pennsylvania voters living in three counties near the Three Mile Island nuclear plant voted against restarting the undamaged reactor adjacent to the one involved in the March 1979 accident.

The vote can't legally affect the Nuclear Regulatory Commission's decision on licensing the undamaged unit that has been shut down for three years because of problems in the steam-generator tubing. Still, its decisive nature can't be ignored, says commission chairman Nunzio J. Palladino. An NRC representative echoes that, saying the vote will be "taken into account to the extent that it can be" within the confines of the commission's mandate.

That sentiment apparently can be ignored by GPU Nuclear, which operates the Three Mile Island plant. President Robert C. Arnold says he is "reluctant to draw firm conclusions" from the vote.

The referendum vote comes on the heels of a federal appellate court decision that requires NRC to consider the pyschological distress a startup of the plant might cause nearby residents. In an unprecedented two-to-one decision that the dissenting judge characterized as "a court-imposed paralysis of nuclear power," the court ordered NRC to tally the "anxiety, tension, and fear" resulting from startup as well as quantifying the possible physical damage to people and the environment.

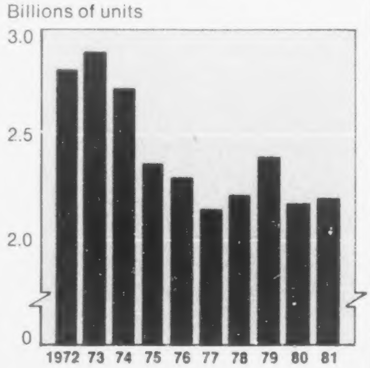
This reckoning would occur in the court-ordered environmental impact statement NRC must complete before licensing a startup of the undamaged reactor. A spokesperson for the commission says staff members are now reviewing the court order, and a decision on whether to appeal the recent court opinion or to complete the required impact statement has not yet been made.

If the decision stands, the language of the ruling is so broad that it could delay startup of the Three Mile Island plant and also affect other nuclear reactor projects and even any large project with federal involvement. ☐

Output of aerosols up a little in 1981

U.S. aerosol production rose 1.5% in 1981 from the 1980 level, according to the latest annual "pressurized products survey" made by the Chemical Specialties Manufacturers Association. At CSMA's midyear meeting in Chicago, survey committee chairman Jay C. Cronin, Sherwin-Williams' national sales manager for aerosol containers, disclosed that an estimated 2.20 billion container "units" were filled in 1981, compared to about 2.16 billion units in 1980.

Aerosol production showed slight upturn in 1981



Source: Chemical Specialties Manufacturers Association

Aerosol production reached a peak of 2.90 billion units in 1973. That year marked the start of the fluorocarbon-ozone controversy. Over the following four years, production declined 26% to a 1977 low of 2.15 billion units. The controversy continues; however, the aerosol industry phased out fluorocarbon propellants and embarked on a pro-aerosol publicity campaign. Production rose again, to 2.23 billion units in 1978 and 2.40 billion units in 1979.

In 1980, aerosol production again dropped sharply (9.8%), to 2.16 billion units, only a little above the 1977 low. That decline was blamed more on the general state of the economy than on lingering effects of the ozone issue. Last year the economy was even worse off, so producers could "pat themselves on the back" for achieving even a small increase, Cronin says.

Personal products continued to be the largest product category in 1981, representing about 30% of the total (compared to more than 50% in 1972). An estimated 644.6 million units were filled, about 1.1% more than in 1980. Household products, the second category, accounted for 575.0 million units, a 0.9% decrease from 1980. Among other categories, pressurized insecticides totaled 173.0 million units, 15.7% higher than in 1980. ☐

Dow asks EPA ruling on chlorinated biphenyls

Dow Chemical Co. has filed a citizen petition with the Environmental Protection Agency to exempt monochlorinated biphenyls from regulations that control polychlorinated biphenyls.

The petition asks that EPA Administrator Anne M. Gorsuch issue a separate rule specific for MCBs because they are different from PCBs. EPA has maintained that, regardless of the scientific arguments, PCBs include MCBs for regulatory purposes.

Dow states in its petition that there is much new evidence demonstrating that MCBs are not dangerous to the environment or to public health. This includes data showing that MCBs are not found in the environment, they do not accumulate in biological tissues, and they have minimal toxic effect potential.

Dow and EPA have been fighting over this issue for almost three years. Dow lost a court case brought by EPA, and could be fined for once selling an insulating fluid containing high levels of MCBs without proper labeling.

The problem started when EPA, as mandated specifically by Congress, was issuing regulations for controlling PCBs. These compounds were defined as "the biphenyl molecule that has been chlorinated to varying degrees." Because the legal definition does not say two or more chlorine atoms, EPA's attorneys insist the agency has to regulate monochlorinated compounds, too. Dow, and some members of Congress, denies that this is what the law intended.

Dow contends that EPA's stance has cost the company more than $13 million so far, but the company will continue to make products containing MCBs because some of them have unique properties. MCBs are found, usually in minute amounts, in some chemical intermediates, heat exchange fluids, and dielectric fluids, the company says. A response on whether EPA will honor the petition is expected in about 90 days. ☐

Balance in innovation involvement being sought

Reagan theme of reducing federal role forces states, universities, and industry to seek new forms of cooperation, but business schools seem to be lagging in improving management of productivity

Wil Lepkowski
C&EN, Washington

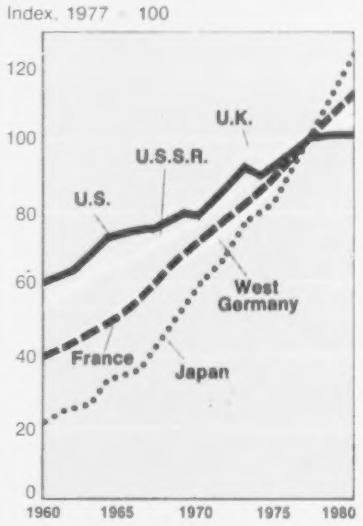
A top to bottom rethinking about America's still-dominant research and development might is emerging. Not only is there a rethinking, but finally, a redoing. In region after region of the country, industrialists and engineering school academics are getting together to search for new ways to collaborate in moving ideas from the concept stage through product development and into markets. But more fundamental to that is the quest to figure out the proper dynamic balance between government and private sector involvement. There is an honest to goodness search now for a viable U.S. technology policy that will carry the country into a new era of global leadership.

No bets are being taken as yet. For America still is wrestling with what it means to be, like industrially sorrowful England, an "overdeveloped" country. What appears to be emerging is a potentially new form of federalism combining the workings of local and state governments with the kinds of industrial initiatives that were so common during the early stages of America's second industrial revolution.

The proper distribution of private and public "technology policies," or stimuli, is being sought all across the country—from Minnesota, where new coalitions are being formed in biotechnology and microelectronics between the state university and various corporations, to North Carolina where the state legislature is investing millions of dollars in research parks where academic research can be moved into industrial application, to Massachusetts where a high-technology council struggles with attempts to find the right mix of state-corporate investments in the development of new industries.

A new beginning is needed, and needed badly, because the national economy continues to look bad. Business bankruptcies, according to Dun & Bradstreet, are at their highest official level in 40 years. Congress and the President are engaged in a knock-down, drag-out fight over the huge $100 billion-plus budget deficit projected for 1983. Interest rates show no signs of falling, though inflation apparently continues to decline. Unemployment is at record levels not only here but in Europe. The productivity figures are miserable in terms of rate of growth. Michigan's economy, so tied to auto manufacture, is practically a basket case. Universities can't find enough qualified engineering professors to meet student needs. Secondary school science education is under the gun. Housing construction is motionless. Steel's decline is leaving the shabby, sooty communities in the Ohio and Monongahela valleys even more squalid. American banks only barely conceal their worries over the default of their loans given to eastern European countries and Argentina. Black youths seethe over the lack of jobs. The chemical industry, already feeling the pain of recession, is beginning to feel breathing down its neck the competition from products made in the newly industrializing countries. And the balance of American trade grows worse.

U.S. productivity growth has lagged since 1976



Note: Productivity defined as output per worker hour in manufacturing industries. Data for 1980 are estimated. **Source:** "Science Indicators—1980," National Science Foundation

So far, the Reagan Administration has adopted no technology policy described by that name. White House sources say that the President could in a few months deliver a White Paper on the subject, but so far there is only silence on the subject, or even a contradiction of thoughts.

For example, whereas White House science adviser George A. Keyworth says that American management is doing a pretty good job advancing U.S. technology, Commerce Secretary Malcolm Baldrige insists that the failure of American productivity has its roots in poor American management. The national consensus seems to be that Baldrige is right and that Keyworth, whose background is physics done at a national weapons laboratory, has a few things to learn.

So does the country, although the proper word might well be "relearn," for the effort seems to involve recapturing a lost magic. U.S. business schools in particular are in need of a shaking up.

At Dartmouth College, Hanover, N.H., for example, two prominent schools of advanced pedagogy sit side by side. One is Thayer School of Engineering; the other is Tuck School of Business. One would think that in this era so shaken by troubling thoughts about America's decline in managing technological innovation, the two places would be buzzing with a joint search for solutions.

Nothing at Dartmouth, however, could be less likely. Tuck sails on by itself with its courses on management theory, leaving Thayer to ponder all by itself such issues as how to make the country more competitive with its more imaginative rivals, Japan and West Germany.

Says Thayer engineering design professor Frederick Hooven, "You can't teach Tuck anything. We have tried hard to initiate types of collaboration between the two schools but with little response. They are highly academic there, while engineering is not seen as a respectable academic subject."

This aversion to bridge-building isn't confined to Dartmouth. It pervades just about all of the country's university campuses, making it a curious, if not a tragic, cultural phenomenon. Study after study shows that the failure of U.S. technology to compete effectively with its foreign competition is a failure of management. Yet the business schools strangely have sat aloof from any responsibility to set things right. Studies of technological innovation primarily have been the domain of the technological and scientific communities with their own self-limiting perspectives and response mechanisms.

Nor can the engineering schools escape their share of fault. At Massachusetts Institute of Technology, for example, a decision was made after World War II to stress not hands-on manufacturing ideas and processes to students but more theoretical academic approaches. The result was the breeding of engineers who knew nothing about problems on the factory floor, or productivity, or working with shop foremen. Since most other engineering schools in the country followed the MIT model, U.S. manufacturing technology began to decline. Meanwhile, West Germany and Japan, with their economic survival at stake, began revving up their managerial engines, setting their sights on winning world (which primarily meant U.S.) markets. Their successes are well known.

And yet, at April's American Chemical Society Middle Atlantic Regional Meeting, a Japanese scientist from Columbia University said the U.S. had only the brightest of prospects, with nothing to fear from Japan. His native country, he said, even envied the U.S. The reason for the envy, he went on, was the continuing dynamism within the American research and development fabric, marked especially by the continuous cross-fertilization of cultures and ideas. Japan had nothing like that, he said, and for that reason America would always be first.

Milbergs: R&D system in a revolution

Lundine: no organized dialogue

The symposium then drifted back into the usual discussions of research and development stimuli, capital formation, and the contradictory policies in Washington. One participant did whisper over the lunch table, "He's right," but nothing more was said.

To assert that the U.S. has no technology policy is, of course, merely the usual play of political cynicism. The government has no technology policy because few people if any know what the term means. If there is a policy, this Administration says it already is in place under the provisions of the Economic Recovery Act Reagan pushed so hard to pass last year. That act accelerated depreciation allowable on new equipment and gave generous tax credits to companies investing in research and development. Other legislation permitted universities to grant exclusive licenses to individual companies on results from government-funded academic research.

But there was a lot the Reagan Administration did not do. For one thing, it refused to implement in any significant way the Stevenson-Wydler technological innovation act passed during the dying days of the Carter Administration. For another, it wouldn't go along with support of the Small Business Innovation Act, which provides set-asides to small businesses of 3% of every agency's R&D budget. The Senate unanimously passed the bill earlier this year. But the House could well reject it. Reagan almost certainly will veto it. Finally, the Administration decimated applied research and science education programs.

But significantly, Reagan did consent to establish in the Commerce Department an Office of Productivity, Technology & Innovation, retaining the very name Carter chose for that same office. Moreover, the Administration said technology and innovation would be given a high order of priority in Commerce, establishing an assistant secretary slot for the subject. Bruce Merrifield, a corporate vice president at Continental Group, was selected for the job and his name went to the Senate for confirmation two weeks ago.

In the meantime, OPTI, which will be under Merrifield, is being headed by former SRI International staffer Egils Milbergs. Commerce will be trying to integrate technology with general economic policy, something never done seriously before.

Milbergs takes an upbeat but modest view of the work of his office. "We see the Commerce Department simply as an honest broker," he says. "We don't want to make government too much a partner with business. The research and development system in this country is going through a revolution. We don't believe any new funding is needed. The problem is how to tie people together."

OPTI's mandate, although soft, appears at least broad. On a budget of $1.8 million and a staff of 32, its job is to:

- Staff the activities of the National Productivity Council.

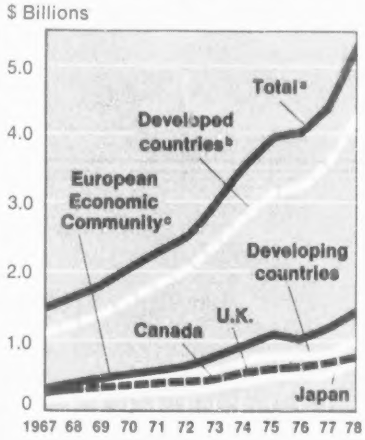
- Study the effect of federal policies, programs, legislation, and regulation on productivity growth, technological development, and innovation in the private sector.
- Be the coordinating focus for all Commerce Department activities in those fields.
- Run a Commerce Department clearinghouse for collection and dissemination of information to the private sector on productivity.
- Run workshops, seminars, and related happenings for business on innovation.
- Carry out the federal coordinating role called for by the Stevenson-Wydler Technology Innovation Act of 1980.

Critics of the Administration would call that last job a joke because the Administration has been doing all it can to rub out the act. One of its features called for establishment of several federally funded centers for industrial technology for development of various "generic" technologies that large sectors of industry use but no industry by itself concentrates on.

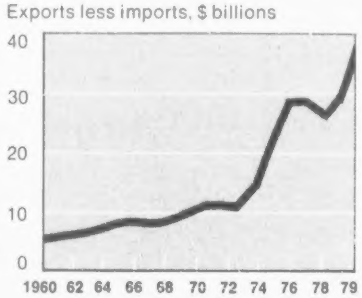
The Reagan Administration likes the idea of generic technology but says if industry considers such centers important, industry can pay for them itself. It made its opinion official by putting it in the *Federal Register*. OPTI, however, would give some staff assistance to any university or company interested in forming such a center.

Milbergs thinks the government can do a lot simply by being a good information broker between government and industry. One policy innovation he says the department is working on is a redefinition of productivity. The traditional definition is, of course, output per manhour. But that definition is passé in a more complex world. "Ideally," he says, "we should relate output to a combination of inputs—labor, capital, energy, materials, and technology—and analyze the relative importance of each to productivity. Currently, there are no official government measures of multifactor productivity, although the Bureau of Labor Statistics has a major program for developing such measures for the U.S. economy. Also, productivity measures do not always account for the quality of inputs or outputs. These are key factors in increasing competitiveness."

U.S. royalties from foreign countries still growing . . .



. . . as is U.S. trade balance in high-technology goods



a Represents net receipts of payments by U.S. firms from both their foreign affiliates and unaffiliated organizations for the use of intangible property such as patents, techniques, processes, formulas, designs, trademarks, copyrights, franchises, manufacturing rights, and management. Excludes film rentals. **b** Includes Western Europe, Canada, Japan, Australia, New Zealand, and the Republic of South Africa. **c** Original six members only. **Note:** Data for 1978 are preliminary. **Source:** "Science Indicators—1980," National Science Foundation

Milbergs says the Commerce Department's Bureau of Industrial Economics is doing a study to develop measures of productivity for about 90 individual industries using the total factor concept. Another project will examine the effects of the shortage of scientific and engineering manpower needed by industry for improving worker output.

The department, he says, already has sent information to companies on the effect of improved management concepts to productivity improvements. These include employee incentive programs, quality control circles, labor-management committees, office automation, new process technologies such as robotics and computer-aided manufacturing, and productivity measurement.

"All too often," he says, "top U.S. managers have stressed quick returns rather than the development of future markets. Management energies have been absorbed with sustaining stock prices to defend against acquisition, rather than focusing on production, quality improvements, and productivity. Management of the next decade is the management of change. The role of management is one of continuous technology updating, human resource development, and strategic planning."

Two approaches the department is taking bear some watching. One is establishment of an office of competitive assessment—temporarily headed by Theodore Schlie—which will make long-term assessments of the competitive outlook for a wide range of American technologies. The second activity is an office of strategic resources under Robert D. Wilson. This office will serve as an information center on key raw materials needed for the functioning of an advanced industrial economy with its endless appetite for exotic metals and alloys.

Keyworth's Office of Science & Technology Policy, while waiting for Merrifield's confirmation to determine its policy role, is not quite standing still. Assistant director of OSTP's life sciences and institutional relations unit Denis J. Prager says the office is tracking the activities of the Business-Higher Education Forum pulled together by the American Council on Education. One of the aims of the forum is to look for ways of improving innovation and productivity in business by better drawing on the know-how of university faculties. The forum is composed of 50 chief executive officers from industry and 50 university presidents. Their goal is to present OSTP with an action plan for no-cost Administration initiatives.

"The other thing," says Prager, "is that we have asked the Industrial Research Institute to provide us with a fellowship that would allow one expert in industrial innovation to work with us. We're a small office, most of us don't know much about innovation, so we could use someone who could work with us for a year." Prager says IRI has agreed to do that and is in the process of picking a fellow.

"What we're seeing," he says, "is a big attempt to bring a better balance among all the players. We may have a science policy, but what we don't have is a technology policy. If we do, it falls apart very quickly when we look at the international marketplace."

In an economy that everyone

Tribus: management measured badly

agrees currently is threatening to fall apart, this Administration isn't free of its critics. The Administration's policy has been to cut corporate taxes so much that new investment capital would be available to industry to modernize and innovate. But will the Reagan tax reform steps actually improve innovation? Studies in the past have shown that industry spends money to invest in new plant and equipment regardless of government incentives to do so. Indeed, the steep rise in industrial R&D spending over the past five years well preceded the previous Administration's initiatives on innovation policy. Thus, there is considerable room for skepticism over whether current government economic policies are relevant at all to producing an innovation climate in the U.S.

There may be, in fact, a built-in reward for the noninnovating company in the Reagan economic scheme. A money-losing company, under current tax law, can sell its unused tax credits to profitable companies and thus be rewarded for not being successful. In fact, the second company, already fat, is rewarded incentives that could lead it to practice complacency.

Furthermore, the Administration still has a policy of protecting companies that are only minimally competitive, such as steel. Protection offers no incentive to do better. For example, protecting the outmoded technology of big steel plants works to the detriment of the smaller, more productive electrical steel plants usually seen in the South.

"If nothing can be done about removing trade restrictions and discovering a better set of policies to promote competition," says economist Burton H. Klein of California Institute of Technology, "it is likely that we will find ourselves in a worse and worse economic predicament. There are many economists who believe that inflation can be kept under control by keeping unemployment at something like 8 or 10%. I do not believe that. Britain has experienced very large price increases in the face of seriously deteriorating economic conditions. And I think that under present policies we are headed for the same catastrophe."

Criticism of Reagan's economic policies comes from all directions, of course, but the "technology policy community" has its complainers, too. One of the more vocal is Rep. Stanley N. Lundine (D.-N.Y.), a member of the House Banking and Science & Technology committees and chairman of the House Task Force on Technological Innovation.

Lundine says that although the Administration's R&D tax credits were a positive idea, "Reagan refuses to conduct an organized dialogue among business, the laboratory, and academia. It refuses to support R&D spending at any reasonable level, and refuses federal support for education."

Lundine believes the Administration could do a lot more to make U.S. high technology more accessible to foreign markets. "We should take some initiative with respect to industrial policy and encourage a dialogue among business and government, labor, and others. This wouldn't be so much like Japan picking winners and losers but instead determining what the particular blockages are to innovation and utilization of new technology. I think Congress should take a serious view of the interface between technology and workers and use it. The human element of innovation has been overlooked. This is where the Japanese have concentrated more than capital investment."

Lundine is backing passage in the House of the highly controversial Small Business Innovation Act, which slipped unanimously through the Senate earlier this year. He is also backing "some kind of national reciprocity legislation that would ensure that U.S. companies be given the chance by foreign countries to sell goods in equivalent amount that they sell to us."

In addition, Lundine is critical of the university business and management schools for ignoring for so many years the understanding of technology and manufacturing in the training of executives. "The only thing we can do in Congress along this line is to expose the problem. The business schools are really way behind the times. For example, at Harvard they are only now requiring a course on organizational development."

Deming: manager works within system

In June, the House Banking Subcommittee on Economic Stabilization, of which Lundine is a member, will be holding hearings on industrial policy. He says he will try to get witnesses to talk about the need to consider the importance of understanding manufacturing and technology on the part of managers. He says he will be looking for labor witnesses with orientation toward getting management and labor to work better together.

The labor forces in the mature industries like auto and steel manufacturing are in tough shape, but Lundine says there are no worker retraining bills on the docket. He thinks, though, that such a thrust is needed as part of a reindustrialization policy. "The other day I heard a bright union guy say Detroit needed as many auto jobs as were being lost because the workers couldn't be expected to learn the new technologies. But I think there are lots of things an intelligent machinist can do. We ought to be thinking about how the government and industry can help these workers get retrained."

One academic who is putting a lot

of energy into policy innovation is Myron Tribus, director of MIT's Center for Advanced Engineering Study. Tribus is a former assistant secretary of Commerce for science and technology. He doesn't think any Administration in Washington will solve the problem of technology policy until it really comes to grips with the productivity problem. And that means getting familiar with what it means to be a good manager in a competitive economy.

"The government is beginning to focus on the problem of productivity," he says, "but not on the solution. If you look at American management, you find that these are bright people. You find that they're aggressive, they're energetic, they work hard, they're dedicated. But just like their workers, they're embedded in a system. They and the people around them don't really understand what their jobs are. And they are measured badly and falsely.

"A former student of mine who started with $15,000 now runs a $100 million business. One time we were talking about managers and he said, 'You know, another guy could come in and take over my job and he could look real good by cutting off research and development.'

"In other words, by doing dumb things in our system, a person can look real good. He accepted that. He didn't question the system, or understand why anybody who was destroying the company could look good. How is that? The reason it is that way is because the image that people have of what it means to be a good manager is inappropriate."

Tribus uses such anecdotes to introduce his listeners to the work of productivity expert W. Edwards Deming, now 81 years old and living in Washington, D.C. Deming is widely regarded as the one responsible for the emergence of Japan as the most innovative industrial power in the world. Brought to Japan by Gen. Douglas MacArthur after the war to help restore its ravaged industrial base, Deming set about educating Japanese industrialists about the kind of management that propelled the U.S. into world industrial leadership in the early years of the century, namely, involvement of management and labor in a unified, nonhierarchical system of production, requiring worker participation in the gathering of data and statistics on the efficiency of the manufacturing process.

The result is what Caltech's Klein saw in a recent visit to an auto plant in Japan—a system "having engineers close at hand who can design new machines and quickly make modifications in existing machines, having a special procedure to test new production equipment before it is committed to large-scale volume production, using 'quality circles' in such a way that they not only improve the quality and reduce the costs of this generation of cars but also supply inputs for the design of new equipment, employing a versatile labor force, designing robots so it is relatively easy to change the production lines, and so forth." For all that, the Japanese give Deming the credit, awarding yearly a Deming Prize to the company best reflecting his ideas.

Branscomb: more than one villain

"The genius of Deming's work," says Tribus, whose center is publishing Deming's latest book next month, "is he understands better than anyone else in the world that the job of a manager is to give consistency and continuity of purpose to an organization to guarantee that workers will have jobs in the future. Nobody else has that responsibility but the manager.

"Deming's second major insight is that people work in a system. That means the job of manager is to work within it, to improve its ability to produce the highest possible quality output at the lowest cost. That's the job of manager, and he [or she] should be measured on it." Tribus, with the zeal of a John the Baptist, says that over coming months he will be preaching the Deming message everywhere he can—to the banking community, to businesses, to Congress. He says the government especially needs educating because he notices on the Commerce Department's Productivity Council, neither Deming nor any disciple of his is a member. "Deming," says Tribus, "has known for a quarter century that unless Americans changed their approach to productivity and quality, the economy would be destroyed."

The council, though, does have Lewis M. Branscomb, chief scientist at IBM and former director of the National Bureau of Standards when Tribus was assistant Commerce secretary. Tribus and Branscomb were seen as a dynamic duo who tried to make the bureau's work more relevant to the environmental, consumer, and industrial needs of the late 1960s and early 1970s.

Currently, Branscomb heads the research and development committee on the Administration's productivity council and as chairman of the National Science Board has been spearheading changes in that body's influence on science policy in the U.S. Branscomb's speeches indicate no discovery of Deming as yet, but he does offer his own diagnosis of the innovation/productivity problem in the context of new federalism connections.

"No single villain can be pinned with the blame: government for overregulating, labor for being too impatient or too reluctant to accept change, banks for being too conservative, business schools for being too theoretical, engineering schools for demotivating students from careers in manufacturing, universities for failing to build graduate computer science capability fast enough, school boards for allowing a deterioration in math and science instruction. All these trends, taken together, spell trouble."

The healing process Branscomb does see appears to be old-fashioned working out of federalism at its best. What is already on view are the beginnings of new alliances among universities, states, and corporations blending their resources for the sake of regional economic development. He likes the view.

"I could easily imagine," he says, "a set of 50 state commissions on education, technology, and development, in which local members of engineering societies might find industry, community, and political leaders who are willing to find out what's going on in other states and see what they could do to help. I think it's more politically legitimate for a state to collaborate with industry in the quest to attract business. And, in this, the states use their greatest asset—their universities—and thus compete with each other. That's a powerful force. State governments, once they get informed and interested, can be an important source of enhancement and encouragement, even investment."

It is a bit curious, however, that Branscomb in his vision of the new technological federalism omits the work of two contemporaries of his while he served in the federal government, one might even say mentors. The first is J. Herbert Hollomon, assistant secretary of Commerce for science and technology in 1962–67, who brought Branscomb in to head the Bureau of Standards. The other is Myron Tribus. Hollomon is currently director of the Center for Policy Alternatives at MIT and recently coauthored with Tribus a paper on new policies needed to improve American productivity derived from the ideas of Deming.

The 1960s were a time, of course, of lots of social and political ferment. Some new policy concepts also were being born at the time. One was the idea of the federal role in regional development. This was born out of President Kennedy's experience of the poverty in West Virginia during the 1960 Presidential campaign. By 1964, Congress had passed the Appalachian Regional Development Act designed to spark the economic revitalization of the 13 states in the Appalachian Mountains. The goal was to attract industry into what it regarded as an inaccessible cultural backwater. After the Appalachian Act came the Economic Development Act established in the Commerce Department. This legislation established various regional commissions around the country with the idea that the federal government would pump money into various job-building programs and projects.

Hollomon took these concepts into the realm of technology. He looked at the history of agricultural development in the U.S., with its network of land-grant schools and research and extension services around the country and asked why not a "technological extension service?" Under this idea, states would combine forces with industry and academia to combine the knowledge generated by researchers in the universities with economic and industrial plans within the states. Out of that concept came the State Technical Services Act, which supplied seed money to the states to set up their programs. Soon, governors began appointing "science advisers," state legislatures were doing the same, and an entire infrastructure began to grow. This skeleton remains today, and seems to be taking on some flesh. Ronald B. Frankum, the deputy director of OSTP, in fact, was a science adviser to Reagan when the President was governor of California.

One more unsung hero deserves mentioning. This one is M. Frank Hersman, who currently works in the general counsel's office at the National Science Foundation. State Technical Services was never too popular with Congress and after about three years was terminated. But the concept was rescued by Hersman, who at the time was running a small intergovernmental programs office at NSF. Hersman continued the labor of establishing science policy capabilities in state governments, usually against the conservative, research-oriented instincts of NSF. After he produced a report for President Ford on technology in the context of federalism, the foundation farmed Hersman out to the Colorado state government, where he helped consolidate science and technology policy structures in the Rocky Mountain region before returning to Washington.

So in a way, the U.S. may be coming back to old-time technological religion by the restoration of a sense of community in the workplace and among universities, corporations, and state and local governments. Little has come forth, however, from the chemical community on that theme. The American Chemical Society has worked hard to establish an interindustry system of support for research universities suffering under diminished federal R&D funding. But such a thrust, although important, skirts the larger issue of a national innovation policy. One ACS member who has been trying especially hard to bring the society to a consensus on innovation is James L. Hecht, research associate of the polymer products department at Du Pont. Hecht organized and chaired a blue-ribbon task force in the Delaware Section of ACS in 1980 to produce a policy statement last year. The statement the task force issued said the most important step the government could take would be to "change the tax laws so as to increase the availability of investment capital and its allocation for productive facilities" by accelerating depreciation allowances for new facilities for production and R&D, introducing tax incentives for new facilities for production and R&D, providing tax incentives to encourage savings and investment by individuals. Some of this the Reagan Administration already has done.

But Hecht says the government should do more to encourage more savings as a source of investment capital and actually produce a strategy that would support the growth of new innovative businesses. "We are still beneficiaries of things that help the rich, not the innovative," he says. Those things should be going into productive facilities, he believes. "If we want to raise the amount going to investment by 4% of the gross national product, that means we have to invest $100 billion per year more than we do now in productive facilities. I think ACS has to come to grips with just what is holding up innovation. When we simply tell Congress to appropriate more for research, we are leading Congress away from the importance of capital investment. In my own view, I think we should tax consumption instead of earnings."

Said pollster Lou Harris last September to a meeting of the Yale University Political Union, "If, by this time next year, inflation is not below 10%, if the prime rate on borrowing is not down to 11 or 12%, if capital investment is not up sharply, if new technology is not being infused into the industrial process, and if the federal budget is not well on its way to being balanced, then the patience of the American people will be stretched to the breaking point. People will say to the management of business, 'Where have you guys been? For 30 years you've been screaming give us a chance. We give it to you and you come up empty.' "

The "cutting edge" issues of the 1980s, according to Harris, will be whether the government should set targets, monitor, and even participate in the capital formation process; whether it should help restore the scientific and technological capability of American industry; and how it can monitor and assist in setting targets and rates of progress toward turning around lagging productivity.

"Be assured of this," Harris said, "One way or another, the American people mean to make this system work." Now the question might be whether American management and technology can speak with the same American voice through what in its purest form once was called the government of the people. □

Chemical capacity use sinks to 60%

The recession has slashed U.S. chemical plant use across the board; output is down 18% with capacity virtually unchanged

William F. Fallwell,
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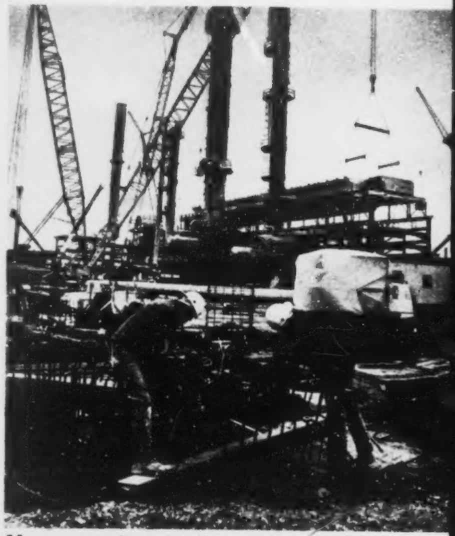
The slow retreat in U.S. chemical plant use rates from last summer has turned into a rout. The recessionary path the industry has been forced to take has become rougher than anyone imagined when the first inklings of a dip interrupted a supposed recovery about the middle of last year.

By the first quarter of 1982, overall use of nameplate plant capacity was beaten back to 60% in basic chemicals, 63% in plastics, and 67% in synthetic fibers, C&EN finds in its latest semiannual survey of the most important products. Last summer, the corresponding use rates were 72%, 76%, and 86% (C&EN, Oct. 12, 1981, page 12).

This means that the none-too-comfortable plant operating rates of 1981 have become painfully low, the lowest since C&EN began its capacity-use surveys six years ago. Until this year, use levels had never fallen below 70%. Now the industry is hobbling along 10 percentage points below the old floor level, and many products are doing even worse.

Behind the averages, a sharp drop in product volume has been the problem. For the 32 basic chemicals in the survey, production is down 18% from both the third and first quarters of 1981. For the five thermoplastics, output is off 15% from the third quarter and 18% from the first quarter. The group of six fibers is down the worst, 21% from the third quarter and 22% from the first.

Meanwhile, capacity itself scarcely has budged over the past 12 months. The industry's steady capacity expansion inherited from the 1970s finally has halted. In fact, there are signs of an eddy current of plant closings pulling down capacity totals for several products. Only a few products still have major expansion waves, and industry analysts are worried about the effects. More typically, potential expansion plans have been shelved quietly for a while.



More capacity is on the way, such as this methanol plant Getty Oil plans to complete in late 1982 in Delaware City, Del.

The brutality of the current recession becomes clear in the across-the-board nature of plant-use cutbacks. Quite a few products escaped major damage in the 1980 recession. By contrast, not a single product now is operating over 80% of nameplate capacity.

Even effective capacity use looks

Plant use falls hard in both plastics and synthetic fibers

	First-quarter 1982			Third-quarter 1981			First-quarter 1981		
	Capacity (nameplate)	Capacity use		Capacity (nameplate)	Capacity use		Capacity (nameplate)	Capacity use	
Billions of lb per year		Nameplate	Effective		Nameplate	Effective		Nameplate	Effective
Plastics									
Polyethylene, low-density	9.7	71%	76%	9.0	84%	89%	8.9	93%	99%
Polyvinyl chloride	8.0	62	72	8.1	75	87	7.8	77	89
Polyethylene, high-density	6.0	66	69	6.0	83	87	6.0	80	84
Polypropylene	5.3	64	71	5.3	77	86	5.1	82	91
Polystyrene[a]	5.4	53	62	5.7	70	71	5.7	68	80
AVERAGE		**63%**	**70%**		**76%**	**84%**		**80%**	**89%**
Synthetic fibers									
Filament yarn									
Polyester	1.9	70	74	1.8	93	99	1.9	82	87
Nylon	1.9	63	67	1.9	84	89	2.0	88	94
Olefin	0.99	64	68	0.94	69	73	0.90	69	73
Staple									
Polyester	2.8	77	82	2.7	97	103	2.8	93	99
Nylon	1.0	56	60	0.97	94	100	0.99	86	91
Acrylic	0.84	71	76	0.83	79	84	0.83	93	99
AVERAGE		**67%**	**71%**		**86%**	**91%**		**85%**	**90%**
OVERALL AVERAGE		**65%**	**71%**		**81%**	**88%**		**83%**	**90%**

[a] Between 5 and 10% of this capacity is shut down. **Sources:** Industry sources, Society of the Plastics Industry, Textile Economics Bureau, C&EN estimates

C&EN's capacity-use indicator—the ground rules

Capacity use at chemical plants is difficult to measure and requires certain assumptions. These bring some order to the maze of variables affecting this critical indicator of the industry's health.

With the help of industry and government sources, C&EN measures capacity use as a percentage of both nameplate and effective maximums. Nameplate capacity is the official design capacity of plants. Effective capacity is the practical maximum after reductions for unplanned maintenance, corrosion problems, changes in product mix, and other influences. Although engineering companies and industry statistics groups try to make nameplate capacity data as "real" as possible, practical problems almost always reduce effective maximums to 85 to 95% of the official totals. For short periods, plants can run more than 100% of effective top capacity, but such a rate won't last more than a few months.

Capacity use is given over as much of a calendar quarter as production data permit, with no seasonal adjustment. The figures are for plants actually running. At present, some products such as ethylene, phenol, polystyrene, and urea have plants temporarily shut down because of weak markets. These plants still are included in capacity totals. The totals exclude new plants just starting up and old plants out of operation for long periods because of accidents. As much as possible, capacity figures stay current with expansions.

Capacity data don't take into account other temporary fluctuations for fuel and electric power interruptions, equipment failure, and feedstock scarcity or substitution. The feedstock variables have been important in the past few years in ethylene production, further reducing maximum output for several coproducts such as propylene, butadiene, and benzene.

Products in C&EN's capacity-use survey are the same as those in the Key Chemicals and Key Polymers series. These are the core products of the industry, the building blocks leading to downstream production of thousands of more specialized products.

pretty feeble at the moment—65% in basic chemicals, 70% in plastics, and 71% in fibers. These are plant-use rates as a percentage of practical maximum output, which is almost always less than official nameplate figures. With the help of industry experts, C&EN gives each product a practical use coefficient, generally 85 to 95% of the official figures.

To be completely realistic, use rates would have to be split further for the two-tier plant structure that has shown up in several products—those pulled out of action for the rest of the recession, and those still running at rates higher than the official average.

The most notorious and far-reaching example is ethylene. Right now, industry analysts say from 20 to 25% of total capacity is shut down—up to 10 billion lb per year, with 1.3 billion lb out for good. This is more than the total individual capacity for half the products on the basic chemical list. The ethylene plants still open are running at about 75% of nameplate capacity.

The ethylene situation, like similar instances in other product groups, has had curious effects on closely related chemicals such as the coproducts from steam-cracking olefins plants. For example, propylene is in far stronger shape than ethylene, since its output has been held way down by the ethylene cutbacks and by feedstock substitution. The result is that the traditional price relationship between the two products has reversed. Instead of propylene's costing 2 to 3 cents a lb less than ethylene, ethylene now sells for roughly 5 cents less than propylene. Propylene's price has been dented slightly in recent months, but nothing like the wreckage in ethylene, which is discounted about 40% from the list price a year ago.

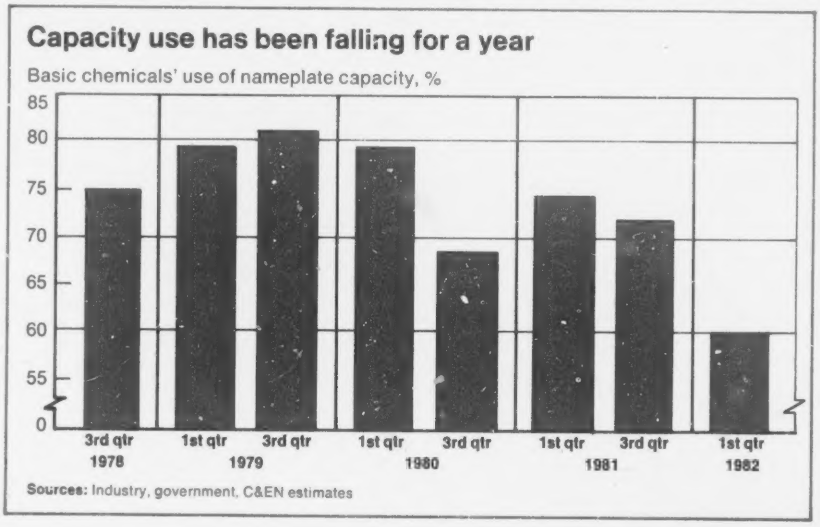
A more long-standing case is the chlorine-caustic soda relationship. Both of these electrolytic cell coproducts are running at historically low rates—62% for chlorine and 59% for caustic in the first quarter. (The normal use rate for these chemicals was 90% or higher until the past few years.) Chlorine's fortunes have sunk so low that some operators consider that it contributes little or nothing to cover plant operating costs. By contrast, caustic has been possibly the industry's most shortage-plagued product of the past few years. Although the worst pinch is past, and caustic's price appears to have peaked for now, its value has shot up tenfold since the 1960s.

The upshot for the chlor-alkalies is a long-expected plant shakeout. It appears to have started, and the new survey shows a slight drop in chlorine capacity. The chlorine figure probably will decline further later this year. Caustic capacity is still rising because operators have installed more evaporators to recover extra product. But caustic capacity will not be able to rise much more.

A third product pair with capacity shutdowns is phenol and acetone. Although the survey doesn't show a permanent capacity loss yet, industry analysts believe that from 5 to 10% of capacity isn't running.

Permanent capacity declines have hit several other chemicals. For example, in *p*-xylene, closings at Hercor and Shell Oil have pulled capacity down to 4.9 billion lb per year from the former 5.6 billion lb. In ammonia, the survey now subtracts 3.2 million tons per year of capacity considered generally shut down over the past few years. The ammonia total is 20.8 million tons.

In other products, sulfur's capacity,


Capacity use has been falling for a year

Basic chemicals' use of nameplate capacity, %

Sources: Industry, government, C&EN estimates

Effective plant use in basic chemicals drops to 65%

Billions of lb per year unless otherwise noted[a]	First-quarter 1982			Third-quarter 1981			First-quarter 1981		
	Capacity (nameplate)	Capacity use		Capacity (nameplate)	Capacity use		Capacity (nameplate)	Capacity use	
		Nameplate	Effective		Nameplate	Effective		Nameplate	Effective
Petrochemicals—olefins and aromatics[b]									
Ethylene	39.7	56%	62%	41.0	65%	72%	40.0	68%	76%
Propylene (chemical and polymer)	23.5	43	47	23.5	59	66	23.5	58	64
Butadiene	4.6	42	47	4.6	67	74	4.6	61	68
Benzene (bg)	2.7	39	43	2.7	67	74	2.5	68	76
***p*-Xylene**	4.9	61	64	5.6	64	67	5.6	75	79
Petrochemicals—C_1 derivatives									
Ammonia (mt)	20.8	80	84	24.0[d]	80	84	24.0[d]	83	88
Urea (mt)[d]	8.1	63	70	8.0	90	100	8.0	88	98
Methanol (bg)	1.5	72	80	1.4	83	92	1.4	90	100
Formaldehyde (37% solution)	8.9	51	54	8.9	65	68	8.9	66	69
Chlor-alkalies									
Chlorine (mt)	14.7	62	65	14.8	78	82	14.7	73	77
Caustic soda (mt)	15.6	59	62	15.5	75	79	15.6	73	77
Soda ash (mt)	10.4	76	80	10.0	83	87	10.0	82	86
Acids									
Sulfuric (mt)	59.4	54	57	58.5	74	78	58.3	74	78
Phosphoric (P_2O_5, mt)[e]	12.4	62	65	11.5	91	96	11.7	94	99
Industrial gases									
Oxygen **Nitrogen** (total, liquid, ttd)	37.6	64	80	36.0	66	83	34.8	63	80
Carbon dioxide (ttd)	17.7	63	70	16.4	71	80	15.6	69	78
Mineral-based inorganics									
Sulfur (total, mlt)	15.7	61	—	16.0	68	—	15.4	76	—
Potash (mt)	2.9	78	—	2.9	76	—	2.9	86	—
Phosphorus (mt)	0.55	66	69	0.55	78	82	0.55	78	82
Plastics monomers									
Styrene	8.7	79	93	8.9	74	87	8.9	82	96
Vinyl chloride	9.6	50	56	9.7	70	77	9.2	65	73
Toluene diisocyanate	0.73	74	82	0.73	81	90	0.73	87	96
Fiber monomers									
DMT-PTA[f]	7.3	58	68	7.3	71	83	7.3	71	83
Ethylene oxide	6.8	68	76	6.8	72	80	6.8	65	73
Cyclohexane	3.1	33	35	3.4	59	62	3.4	62	65
Adhesives and coatings monomers									
Phenol[g]	4.0	56	62	4.0	67	74	3.6	69	77
Vinyl acetate	2.4	72	73	2.4	79	83	2.5	78	82
Pigments									
Carbon black	3.4	75	83	3.4	82	91	3.7	76	84
Titanium dioxide (mt)	1.0	53	62	1.0	82	96	1.0	77	91
Solvents									
Acetone[g]	3.6	59	66	3.6	58	65	3.5	58	65
Ethanol (mg)	270	50	53	270	56	59	270	65	69
Methylene chloride	0.83	54	60	0.83	64	71	0.83	75	83
AVERAGE		**60%**	**65%**		**72%**	**79%**		**74%**	**81%**

a bg = billions of gal, mt = millions of tons, tt = thousands of tons, ttd = thousands of tons per day, mlt = millions of long tons, mg = millions of gal. **b** About 25% of ethylene and lesser amounts of other capacity currently is shut down because of weak markets. **c** Total extraction capacity, which runs about 25% more than basic production capacity. **d** Some capacity, probably less than 15%, shut down. **e** Includes both wet-process and furnace-process capacity. **f** Dimethyl terephthalate and purified terephthalic acid, not including acid converted to DMT. **g** Up to 10% of capacity currently shut down. **Sources:** Industry and government sources, C&EN estimates

at 15.7 million long tons per year, is rated less in 1981 because of depletion at mines, which is running ahead of new sulfur recovery capacity at refineries and smelters. Two plastics monomers, styrene and vinyl chloride, also are rated less than in 1981 because of small shutdowns. And cyclohexane capacity has fallen 9% to 3.1 billion lb per year with Commonwealth Oil Refining's closing in Puerto Rico.

Basic chemicals with capacity going in the opposite direction are few—most notably soda ash, methanol, and the industrial gases, all of which have substantial investment campaigns with more on the drawing board. The big acids, sulfuric and phosphoric, also have added to capacity in the new survey, but analysts in this area think the bloom may be gone with the newfound troubles in fertilizer markets. Some capacity in both products is thought to be shut down. Similarly, urea shows a small capacity increase.

The scarcity of big new capacity likely will complement low utilization of existing capacity throughout this year. □

Polypropylene brightens outlook for olefins

As jokes go, it wasn't really all that funny: The British fleet actually was going down to Argentina not to recover the Falklands but to sink the barge-mounted polyethylene plant in Bahia Blanca. But for a gloomy group of researchers assessing the current overcapacity situation in polyethylene, at a Chemical Marketing Research Association session on olefins and other plastics, it drew appreciative—albeit rueful—laughter.

Indeed, several of the titles of the talks were illustrative of the depressed conditions in the plastics industry—"Shakeout in polyethylene," for example, and "Rationalization of PVC." Coupled with the news that even the heretofore highly profitable field of engineering plastics is on the brink of being overwhelmed by new suppliers and capacity, that left only the report that business is picking up for polypropylene.

With a slight cutback in polypropylene capacity—down to 5.25 billion lb per year this year from 5.5 billion lb in 1980—capacity utilization is picking up to 78% this year from the bleak 67% in 1980. And there is enough demand ahead to boost that to 94% by 1985, reported James J. Driscoll, marketing and sales manager of polypropylene at USS Chemical Co., the chemicals subsidiary of U.S. Steel. By then, he adds, capacity will have expanded again to an expected 5.43 billion lb per year.

Most promising areas for polypropylene, he says, would be in such specialized areas as resins for packaging films, random copolymers, and controlled-rheology fibers and plastics. Those kinds of applications will help fuel growth of just above 6% per year through 1990, he predicts.

However, those encouraging words about polypropylene were among the few heard at the session. And even the CMRA sessions themselves were hard-hit by the economic hard times, with only about half the normal attendance of 500 showing up for the annual New York City spring meeting.

According to Frederick A. Hajduk, director of company development at Chemplex Co., Rolling Meadows, Ill., there will be solid growth, 8% per year, over the decade for high-density polyethylene, and somewhat slower 3%-per-year growth for low-density polyethylene. The industry will continue to be plagued, however, by the overcapacity that has held the average operating rate for the HDPE industry to 80% from 1973 to 1981, and that of LDPE at about 85%. The industry's jump to linear low-density, he adds, will further confuse the situation. "Within the next few years, all producers will have some capacity that can be changed rapidly to produce resins across the entire density range," Hajduk says.

Chemplex has developed three scenarios for polyethylene, he notes. One is built upon the company's own predictions of energy consumption and prices, as modified from forecasts by the Department of Energy, and forecasts of economic and inflationary conditions. Under this scene, HDPE will grow 7.7% per year through 1990 to 9.72 billion lb; LDPE will decline 5.7% per year, to only 3.5 billion lb; and LLDPE will grow 35.1% per year to 6 billion lb of demand by 1990.

A less optimistic scenario assumes that energy and feedstock costs will be 10% higher than those in the base forecast, holding HDPE to about 6%-per-year growth through 1990; hastening a decline of LDPE with sales falling an average of 12.7% per year; and spurring LLDPE even more, by an average annual growth of 36%. Correspondingly, if the costs of energy and feedstocks are 10% below those of Chemplex's base forecast, the company expects HDPE to grow an average annual rate of 9.3% through 1990; LDPE to decline only 2.2% per year; and LLDPE to grow at an average clip of 33.6% per year.

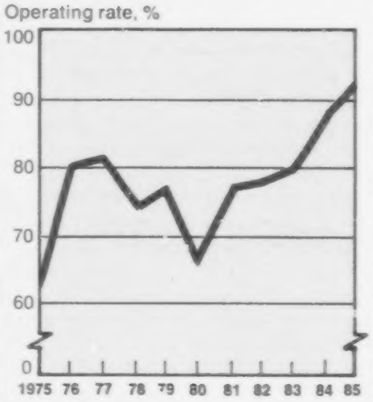
By the company's base-forecast predictions, the total polyethylene industry operating rate will be 110.5% by 1990. But as of 1985, it still will be only 84% of capacity.

Polyvinyl chloride faces a similar picture: slowing growth and relatively low capacity utilization rates. With an average annual growth rate of 12% in the 1960s, dropping to about 8% in the 1970s, PVC faces further maturation of its markets, leading to an average growth of less than 5% per year through this decade, reports Elliot A. Vogelfanger, manager of planning at Conoco Chemicals.

The industry is showing all the signs of a maturing industry—slowing of growth, high competitiveness with decreased bargaining positions for producers, need for a low-cost production position, and revenue constraints, Vogelfanger notes.

It also is an industry going through a massive change in technology. In 1970, small reactors made up 100% of PVC production. But by 1980, more than 60% were produced in large-scale reactors using latest technology, with more efficient yield. By one estimate, present PVC capacity is 7.5 billion lb per year, but even by 1984, demand will reach only about 7.4 billion lb.

Operating rates for polypropylene to improve



Source: USS Chemicals

Result? Producers will selectively shut down older, smaller equipment, Vogelfanger predicts, to help take the pressure off capacity—but also to make the competition for those companies remaining in the PVC business even more intense. And the prospects of an industry switch to even more efficient third-generation technology would intensify further the competitive picture, he adds.

In the meantime, the diverse world of engineering plastics will attract increasing numbers of competitors, to the point that returns on investment may be seriously affected, predicts Richard M. Kossoff, president of R. M. Kossoff & Co. consultants in New York City. Although the industry grew an average of 11% a year during the 1970s and into 1981, and will continue growing at nearly 10% per year through 1986, "Many segments of this business had unsatisfactory returns on investment, and it will get worse," he predicts.

The business is difficult to enter, he points out, because of patent protection for some polymers, the high capital investments involved, and what frequently runs 10 to 15 years to get a positive cash flow. Nonetheless, he predicts that the number of suppliers of engineering plastics will jump to 49 by 1992 from 32 in 1982, with Japanese suppliers accounting for 39 of those. Producers will tend to concentrate on just several basic polymer families, rather than try to offer broad product lines, and will concentrate on specialty grades, and on alloys with existing polymers. □

Sulfur market faces weaker year or two

After a decade of radical change in the 1970s, sulfur emerged in robust shape for the start of the 1980s. With twin strengths of a supply pinch and a booming market in phosphate fertilizer, sulfur enjoyed one price increase after another. It also enjoyed a forecast of supply tightness for years to come.

But events of late have disrupted the unanimity on its future. A fresh forecast at the Chemical Marketing Research Association meeting in New York City goes along with the optimism for the long run but warns that sulfur could be in for some weakness over the next year or two. Oddly enough, the problem could be oversupply, says Darrell G. Rangnow, sulfur specialist at Pace Co. Consultants & Engineers of Houston.

For 1983, Rangnow forecasts that exports of sulfur from Saudi Arabia, now entering the market, will reach 2 million metric tons. (For perspective, U.S. sulfur production currently runs about 10 million metric tons a year.) In the U.S., as much as 500,000 metric tons of new sulfur could come from recovery plants fed natural gas from the Overthrust producing area in the West. Sulfur from the Overthrust area depends on completion of a key gas pipeline project.

Meanwhile, a modest recovery in sulfur demand will occur as both the fertilizer market and overall industrial production improve. However, the demand recovery will not be large enough to offset the 2 million to 3 million metric tons of excess worldwide production. The surplus will go into inventories, which have been very low until just recently.

Accompanying the surplus will be geographic sales switches, Rangnow says. Exports of Canadian sulfur through Vancouver will decline as Saudi Arabian sulfur replaces it in places such as India, Tunisia, Morocco, and southern Europe. Competition from Overthrust sulfur in Canada, combined with Canadian exporters' need for cash, will push some Canadian sulfur down to the big Florida phosphates outlet. As Canadian sulfur moves into Florida, Rangnow believes that U.S. Frasch (mine) production will continue to decrease. At the same time, sulfur prices might weaken, marginal mines could be shut down, and U.S. exports could decline because of the competition from Canada and Saudi Arabia.

Longer term, however, Rangnow thinks that sulfur prices will firm through the end of the decade. Prices will be high enough to justify development of new sulfur sources.

So far in 1982, price weakness hasn't developed for contract sulfur on the Gulf Coast, according to Rangnow. He believes the reason is that Frasch sulfur producers have been able to reduce production selectively and increase inventories from their critically low level of the past few years.

Beyond this year, two major long-term changes will continue for sulfur demand, Rangnow says. One is that developing countries will require much more sulfur than before, increasing dramatically their share of sulfur consumption. Developing countries also will be a larger source of supply for sulfur during the 1980s.

Second, the already strong tie between sulfur and the world fertilizer market will get even stronger during the 1980s. This could mean continued erratic demand for sulfur because of the connection to agriculture, whose commodity products tend toward wild price movements.

On the supply side, gradual depletion of sulfur minable by the Frasch technique—using hot water to melt the sulfur underground and air to lift the sulfur to the surface—will be offset by increased output of sulfur recovered from sources such as natural gas, petroleum, and ores. Because of their increasing prominence, producers of recovered sulfur will take a more active role in marketing sulfur.

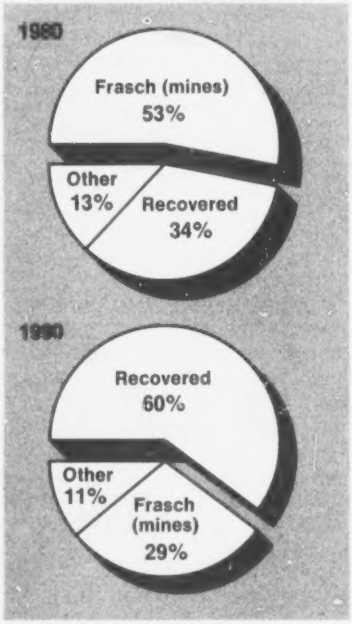
By 1990, demand for sulfur in the U.S. and Western Europe will account for about 42% of the total worldwide demand, down from nearly 49% in 1970. Demand in developing nations will surge to 27% of the total from 17% in 1970.

On the supply side, in 1990 the Canadian and Western European share of the total will be down to 23% from 31% in 1970. The U.S. share will increase a bit to 25%. Other producer categories—noncommunist countries, Asia, and the Middle East, will provide 21%, up from 14% in 1970.

In the U.S., supply of Frasch sulfur will sink to just 29% of the 1990 level, down from 74% in 1970. Recovered sulfur will take up all of the share lost by Frasch, growing to 60% in 1990 from 15% in 1970.

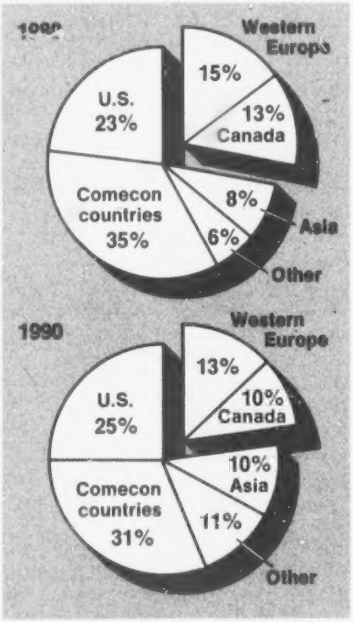
The U.S. use pattern for sulfur will continue its shift toward the fertilizer industry with 60% of sulfur going there in 1990, up from 39% in 1970. Use of sulfur to make industrial sulfuric acid will decline to 30% in 1990 from 46% of the total in 1970. □

U.S. sulfur sources will flip-flop in the 1980s



Source: Pace Co.

Sulfur supply from Europe and Canada will decline



Source: Pace Co.

U.S. chemical exports face sharp decline

Competition from world-scale plants now under construction in countries with low-cost energy will cut into export markets for U.S. chemicals

During a recent meeting of the Chemical Marketing Research Association in New York City, two U.S. chemical trade experts gave back-to-back forecasts of what world trade will be like for U.S. chemical companies during the remainder of the 1980s.

Each disclaimed that they were forecasting gloom and doom. But there was little in the analysis of either one that radiated optimism.

Myron T. Foveaux, legislative representative for international trade and economic policy at the Chemical Manufacturers Association, took a qualitative approach. Paul A. Cook, manager of chemical services at Data Resources Inc.'s Houston office, went the quantitative route. Both, however, reached the same conclusion: The eighties will be less than rosy for U.S. chemical exports.

"[Chemical] export markets will be lost as new plants come on stream in Canada, Mexico, and [Organization of Petroleum Exporting Countries]," says Foveaux. "By the late 1980s, today's rather large exports of some products will be replaced by net imports and a much lower level of exports for others."

Cook echoes these sentiments. During the latter half of the seventies, the spectacular increase in net chemical trade sustained, in large part, the strong growth in U.S. chemical production. One primary reason for the export surge, Cook says, was the significant raw material cost advantage that U.S. petrochemical producers had over their foreign counterparts.

But now that U.S. energy prices essentially have reached world levels, much of that cost advantage has been lost. "It is unlikely that the present high level of [chemical] exports can be sustained," says Cook.

Like Foveaux, he sees competition from the world-scale plants now being built in countries with low-cost energy eroding U.S. chemical export opportunities. And, like Foveaux, he expects that some U.S. companies will feel the impact of increased imports in some product areas.

Data Resources, which regularly keeps tabs on about 100 chemicals ranging from basic building blocks to final products, forecasts a decline in U.S. chemical exports on a volume basis through the rest of the decade. The reversal, in fact, became noticeable last year, in part because of the strength of the U.S. dollar.

Exports of aromatics derivatives, in particular, Cook says, already have declined abruptly in 1980 and 1981. Exports of ethylene and propylene derivatives also have dropped—and will continue to drop. But, compared to aromatics, they will hold up fairly well until 1985. That's because these products are based on low-cost, natural gas-based feedstocks. After that, world-scale plants outside the U.S., based as they will be on even less expensive ethane and propane, will threaten U.S. exports of ethylene and propylene derivatives seriously.

Between 1980 and 1985, Cook expects U.S. net chemical trade to drop to 4.2 billion lb from 9.4 billion lb. That's a 5.2 billion lb swing, which represents an average annual decline of 15%.

Should this happen, it will have a serious impact on the U.S. chemical industry. Cook estimates that between 1975 and 1980, U.S. petrochemical production grew an average 7.3% per year. This was possible only because a chemical export growth of 26% per year substantially reinforced demand in the U.S., which increased only 5.3% annually. Between 1975 and 1980, Cook emphasizes, exports accounted for fully one third of the growth in petrochemical output. Exports are a major reason why the industry grew at twice the growth rate of the gross national product.

But if net petrochemical exports drop as Data Resources expects through 1985, the impact will be felt in U.S. petrochemical production. The company estimates that U.S. demand will grow 5.1% per year between 1980 and 1985. But the 15% average annual decline in net petrochemical exports will restrict the growth of petrochemical production to only 2.9% annually. Between 1980 and 1985, then, fully one third of growth in U.S. demand will be offset by the net trade decline. The industry multiple becomes only 1.5 times GNP growth.

In addition to lost chemical export

Exports will become less of a factor in U.S. chemical production . . .

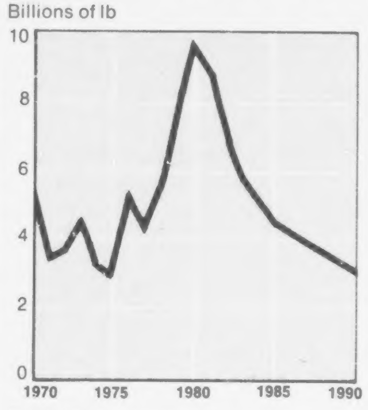
Product and derivatives	Per cent of demand 1980 Exports	 1980 Imports	 1981 Exports	 1981 Imports	 1990 Exports	 1990 Imports
Ethylene	16.4%	3.1%	15.2%	3.6%	7.5%	3.7%
Propylene	19.5	4.9	19.3	5.6	8.9	4.2
Butadiene	18.6	18.8	14.2	16.5	7.4	10.7
Benzene	21.4	8.0	20.4	10.4	9.4	8.0
p-Xylene	36.7	2.2	38.3	2.6	16.3	2.6

. . . and their decline will affect growth rate of petrochemicals output

Billions of lb	1975	1980	1985	% average annual growth, 1975–80	% average annual growth, 1980–85
Trade balance	2.9	9.4	4.2	26.0%	−15.0%
Domestic use	40.4	52.3	67.1	5.3	5.1
Production	43.3	61.7	71.3	7.3	2.9

Source: Data Resources Inc.

U.S. primary petrochemicals face decline in net trade



Source: Data Resources Inc.

markets and increased import pressure, Foveaux is particularly concerned about the impact that governmental action—both in the U.S. and abroad—will have on commodity chemical production. Energy policy, tax incentive, subsidization, and even production by governments in Europe, Canada, Mexico, and OPEC countries, are new forces to be reckoned with, he says.

With this in mind, Foveaux asks, what is U.S. government policy on petrochemicals? His answer: There isn't one.

Two studies assessing the competitive stance of the U.S. petrochemical industry are under way—one by the Department of Commerce, another by the International Trade Commission. These indicate a government interest in petrochemicals, says Foveaux, but beyond that, there are no initiatives to encourage a strong petrochemical industry. And to add insult to injury, both the Administration and Congress seriously are considering an oil import fee; such a fee would put the industry at a further disadvantage.

If the U.S. chemical industry's involvement in petrochemicals declines as predicted, Foveaux believes that companies will become more involved with specialty chemicals. The problem, of course, is that this field can become overcrowded if too many chemical companies try the same solution. □

Chemical needs shifting in South America

South America has been and will continue to be an important market for chemical exporters. But within the area, national markets are changing constantly. Product requirements also are shifting.

As a result, export hopefuls must keep their market analysis up to date if they expect to take advantage of the chemical export opportunities that exist in South America.

That's the message that William D. Gersumky brought to his audience at the recent Chemical Marketing & Research Association's review and forecast meeting in New York City. Gersumky, who is head of SP Latin America, Cornish, N.H., believes that the rewards are worth the effort. He estimates that South American countries imported about $5.5 billion worth of chemicals last year. Based on Department of Commerce figures, U.S. companies enjoy an estimated 40 to 45% of this business.

Brazil's plastics imports are being replaced by local production

Imports, millions of $ (U.S.)	1981	1980
Low-density polyethylene	$3.2	$35.2
High-density polyethylene	3.2	4.2
Polypropylene	1.3	1.9
Polyvinyl chloride	3.9	20.3
Polystyrene	1.2	2.1
Acrylonitrile-butadiene-styrene	1.0	1.5
Polyvinyl acetate	5.4	5.3
Polyvinyl acetate/polyvinyl chloride	3.5	3.6
Acrylate/methacrylate	3.5	7.1
Polyacetal	1.7	na

na = not available. **Source:** SP Latin America

As Gersumky sees it, the potential for chemical exports to South America will continue to expand, even though some countries there are expanding and diversifying their own chemical industries and making them more sophisticated. However, as South American chemical import requirements increase, the content of the total import basket will be changing.

For instance, he says that companies that had been shipping polyolefins to Brazil, Argentina, and other South American countries may find that the gravy days are over. Companies that export plastics additives or fancy processing aids may find that their days are just beginning.

The good times may be over for exporters of monomers and other bulk petrochemicals. But the future is promising for exporters of fine chemicals, photographic and reprographic chemicals, specialty paper coatings, and many other specialty chemicals.

Argentina still needs chemical imports

Thousands of metric tons	Production	Imports	Exports
Sulfuric acid	226	—	—
Benzene	120	—	40
Caustic soda	107	45	—
Ammonia	54	—	—
Styrene	50	6	—
Methanol	36	—	4
Polyvinyl chloride	33	20	—
Low-density polyethylene	32	33	—
Phthalic anhydride	15	—	2

Source: SP Latin America

Gersumky says there are four types of chemical products that offer the best prospects for sales to South American markets:

- Products with no raw materials base at reasonable cost (such as soda ash).
- Sophisticated or specialty products for which local market size cannot justify the required plant investment.
- Workhorse products for which local capacity is not yet built up, or for which market growth has outpaced the rate of new plant investment.
- Proprietary formulations that have distinct advantages over locally produced products.

Gersumky concentrates his analysis of South American chemical markets on Brazil and Argentina. These two countries alone account for about 80%, or $4.4 billion, of all South American chemical imports. In addition, the two countries are supplying significant and growing volumes of chemicals to their South American neighbors, especially Bolivia, Paraguay, Chile, and Uruguay.

Argentina, of course, is a country in trouble. It has been in trouble since long before the Falklands crisis.

The greatest curse of the Argentine chemical industry has been the superprotectionism of past decades that allowed companies there to build and operate undersized and uneconomic plants. A 15,000 metric-ton-per-year polyethylene plant is only one example.

High-priced products from such plants, coupled with a rapid dismantling of Argentina's tariff walls, have convinced chemical buyers there that importing is the least expensive way to secure supplies.

Gersumky tabs heavy inorganics, such as soda ash and caustic soda, as the best bets for U.S. exporters to Argentina. "We have long since ceased to predict when Argentina's long-overdue . . . soda ash plant will actually come on stream," he says.

Argentina produced 32[illegible]00 metric tons of low-density polyethylene last year, but required an additional 30,000 tons of imports. Most of these imports came from Brazil, which also supplied more than half of Argentina's high-density polyethylene requirements.

Argentina imported an estimated $700 million worth of chemicals in 1981. And, says Gersumky, its import needs run the gamut from basic chemicals, plastics, and intermediates, through a long list of specialties.

Brazil is the largest single chemical market in South America. In 1981, it imported an estimated $3.7 billion worth of chemicals, plastics, and related materials.

However, says Gersumky, the Brazilian government is making it tough on outside chemical suppliers. It tries to entice you to produce locally, he says, by making it difficult and expensive for Brazilian companies to import. It also encourages them to use alternate local products, even if these products are inferior.

Meanwhile, Brazil has built a modern petrochemical industry, complete with downstream industries. It no longer imports the basics, intermediates, and plastics in large volumes as it once did. In fact, it now is a significant exporter to other Latin American countries of chemicals such as polyolefins, acrylonitrile, and ethylene glycol.

Last year, Brazil exported almost $700 million in chemicals and plastics. About half of this went to neighboring countries in South America.

The "export or die" idea has caught on in the Brazilian chemical industry. And, says Gersumky, it is no temporary phenomenon of getting rid of excess production.

Despite this, Brazil's chemical import requirements remain substantial. It imported $3.7 billion worth of chemicals and related products in 1980, more than half of which were organics and specialties.

Some of this demand could disappear when the Norquisa S.A. plant comes on stream at the Camacari petrochemicals complex. Norquisa has a mandate to build a $70 million, multipurpose aromatics conversion plant to produce some or all of the 40 or more intermediates that Brazil now imports. □

CHECKOFF

PLANTS

■ **Canada**—Celanese Canada has received industrial development permit from Alberta Provincial Cabinet to construct world-scale acetic acid and vinyl acetate manufacturing facilities at its Edmonton, Alta., site. Capacity for $508 million facility was not disclosed. New plants will get their primary methanol feedstock from firm's $261 million, 4.6 million lb-per-day plant nearing completion at site.

■ **East Germany**—VEB Chemiekombinat has completed chlor-alkali plant at Bitterfield, north of Leipzig. Plant contains 104 diaphragm cells from Diamond Shamrock with capacity to produce 309 tons per day of chlorine and about 470 tons per day of caustic soda. It marks first time that diaphragm cell has been licensed into German Democratic Republic.

■ **Indonesia**—Kellogg Overseas Corp. and Thyssen Rheinstahl Technik as joint venture have been awarded contract of more than $1 billion to supply aromatics plant for Perusahaan Pertambangan Minyak Dan Gas Bumi Negara (Pertamina). Facility, which will process 30,000 barrels per day of naphtha, will be located in Plaju, Palembang, South Sumatra. Complex will produce benzene, toluene, *p*-xylene, *o*-xylene, cyclohexane, and nominal amounts of other coproducts. It also will contain 500 million lb-per-year purified terephthalic acid unit.

■ **Luxembourg**—Du Pont will build $55 million world-scale Hytrel polyester elastomer plant to serve markets in Europe, Middle East, and Africa; completion is scheduled for 1984.

■ **Saudi Arabia**—Foster Wheeler subsidiaries have signed contracts for overall management, engineering, procurement, and construction of $900 million petrochemical complex at Al-Jubail. Project includes 1.1 billion lb-per-year ethane cracker and 400 million lb-per-year linear low-density polyethylene plant capable of producing both low- and high-density polyethylene. Contracts are with Arabian Petrochemical Co. Petrokemya, partnership between Saudi Basic Industries Corp. (SABIC) and Dow Chemical Saudi Arabia Ltd.

■ **Japan**—M&T Chemicals has signed joint venture agreement with Yoshitomi Pharmaceutical Industries Ltd., Osaka, to warehouse and distribute organotin chemicals in Japan and other Far East markets. Joint venture will be called M&T-Yoshitomi Chemicals Ltd.

■ **Spain**—PPG Industries and several investors of Barcelona have formed companies to make, supply, and service Spanish automotive market with high-technology coatings, mastics, and sound-deadening products. New firm, of which PPG will have 60% equity with its affiliated company in France, Peintures Corons S.A., will be called Peintures Pittsburgh Ibericas S.A., headquartered in Barcelona.

ACQUISITIONS

■ **Australia**—Plastics operations of General Electric Co. has purchased engineering thermoplastic assets of M. E. Hogg Australia Pty., Dandnong, Victoria. M. E. Hogg has been manufacturing licensee for Lexan, Noryl, and Valox engineering thermoplastic resins since 1972. It also provides mineral- and glass-filled resins to Australian and New Zealand markets.

■ **Mexico**—G. D. Searle has acquired Recordati de Mexico S.A., pharmaceutical company that produces gastrointestinal treatments, throat preparation, vitamins, anti-infectives, and other products. It had 1981 sales of $6 million.

■ **Netherlands**—National Starch & Chemical has completed purchase of 50% interest it did not own in Delft-National Chemie from Gelatine Delft. Delft-National Chemie has headquarters, laboratories, and manufacturing facilities in Zutphen, the Netherlands, and additional plants and laboratories at Delft, the Netherlands, and Speyer, West Germany. Delft-National is producer of adhesives and resins.

Chemical
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NEWS
May 31, 1982

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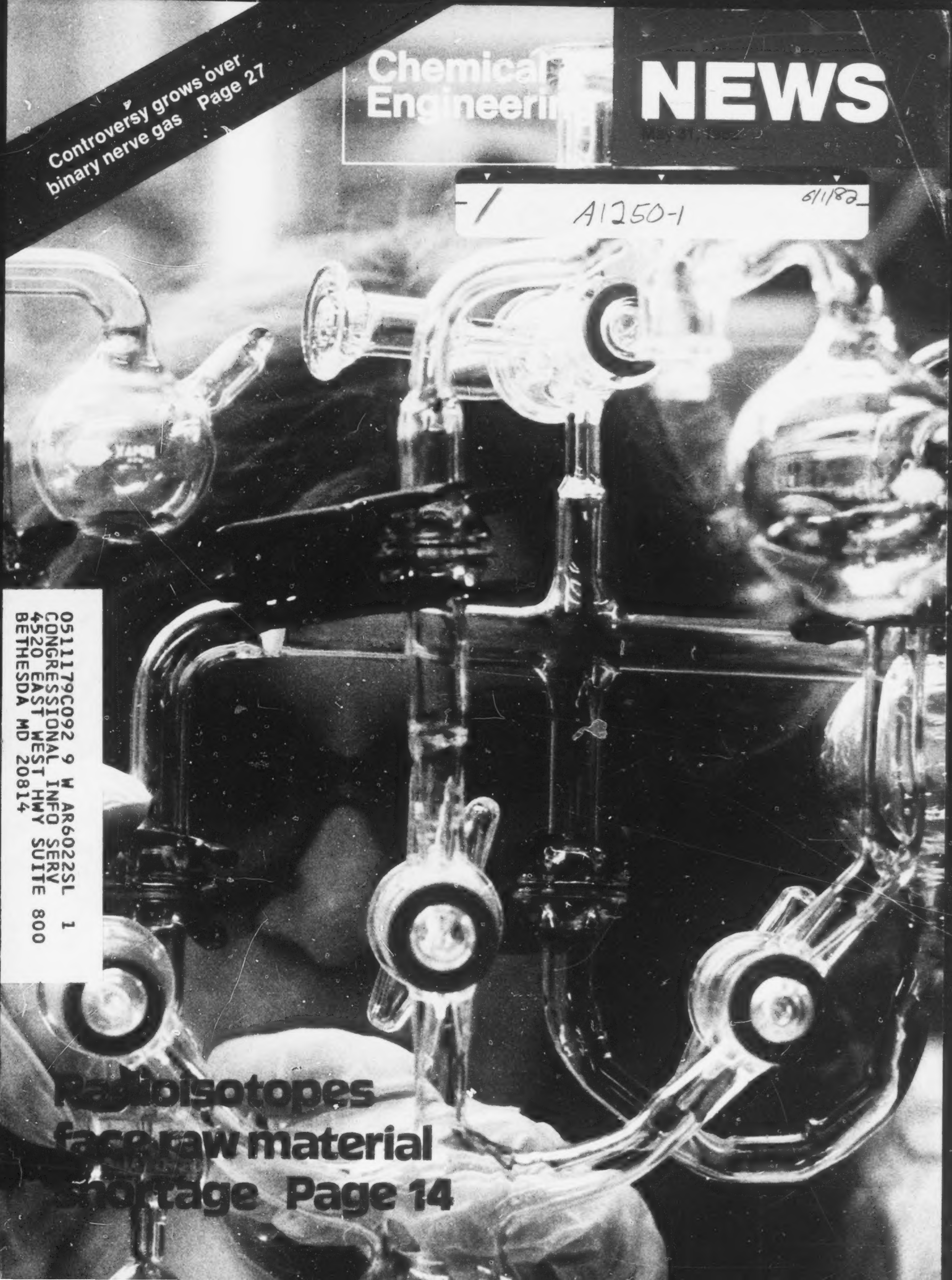
Controversy grows over binary nerve gas Page 27



Radioisotopes face raw material shortage Page 14

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Chemical & Engineering NEWS

Cover: Maze of glassware is part of New England Nuclear's Boston facility for making radioactive chemicals

4 Letters

Concentrates
12 Business
24 Government
33 Science/Technology

The Departments
40 ACS Comment
44 Meetings
56 Newscripts

News of the Week

- ***Department of Commerce will inherit*** *most of the Department of Energy under current dismantlement plan.* ***Page 6***
- ***EPA grants superfund money*** *to clean up PCB wastes in North Carolina.* ***Page 7***
- ***New company formed*** *to combine world of computers with biotechnology.* ***Page 7***
- ***Celanese's cutback*** *of polyester filament spinning capacity and yarn price boost encourage other producers.* ***Page 7***
- ***Mortality study of workers exposed to formaldehyde*** *shows no excess of deaths due to cancer, Du Pont says.* ***Page 8***
- ***Control of Gulf Resources & Chemical*** *is subject of major proxy fight.* ***Page 8***

Business

- ***Radioisotopes,*** *an expanding industry, face a cloudy future unless supply problems can be rectified.* ***Page 14***
- ***Lower costs make soda ash*** *look more attractive, cause shift in demand away from caustic soda.* ***Page 18***
- ***Mobil's process yields new monomer*** *for plastics; 35 million lb-per-year plant gearing up for startup.* ***Page 20***

International

- ***Venezuela's petrochemical industry*** *may show a profit this year as government-owned Pequiven smooths operations.* ***Page 22***

Government

- ***Senate votes funds for chemical warfare*** *program but doubts about field testing, European deployment unresolved.* ***Page 27***
- ***Volume of treated hazardous wastes*** *declined in 1981 from the previous year even though capacity increased.* ***Page 32***

Science

- ***Chinese scientists synthesize biologically active yeast alanine tRNA*** *containing rare nucleotides after 20 years of effort under difficult conditions.* ***Page 35***

Technology

- ***Process to upgrade main components of lignocellulosic materials*** *using inexpensive chemicals developed in Geneva.* ***Page 38***
- ***New products to treat boiler feed water*** *minimize scale buildup, reduce need for cleaning, developer Nalco says.* ***Page 39***
- ***Curing system*** *for ethylene-propylene-diene monomer used in single-ply roofing allows curing in place.* ***Page 39***

ACS News

- ***ACS membership dues rise to $62*** *in 1983; allocations to C&EN and to local sections also increase.* ***Page 42***
- ***Committee on Analytical Reagents*** *updates specifications on entries for 7th edition of "Reagent Chemicals."* ***Page 42***

Superfund to help clean up PCB-laced soil

They're called midnight dumpers. Last year four of them were convicted in federal court for deliberately releasing in 1978 more than 30,000 gal of waste transformer oil laced with polychlorinated biphenyls along 211 miles of highway shoulders in North Carolina. Last week, with superfund money, the Environmental Protection Agency agreed to help the state clean up this unique hazardous waste dump.

With nearly $2.6 million from EPA plus the $285,000 it already has spent, North Carolina will remove and dispose of a staggering 40,000 cubic yards of PCB-contaminated soil from highway shoulders in 14 counties. The soil will be buried in a secured landfill now being built in Warren County, solely to receive the PCB-laden waste. The state plans to complete the landfill in seven weeks. William Phillips of the state's Department of Transportation says the contaminated soil will not be pretreated before burial.

Additionally, the state is developing a detailed soil sampling and analysis plan to aid in the safe removal of the soil. No unreasonable risk to the environment or public health is expected from the cleanup. A trial run of the soil removal procedures in 1978 uncovered no adverse air or water effects.

Cleanup is expected to be completed by this fall. That includes reconstruction of the excavated highway shoulders as well as landfill construction and soil removal and disposal.

According to EPA Administrator Anne M. Gorsuch, the agency has approved nearly $54 million in superfund money. Approval has been given for remedial cleanup at 53 of the 115 top priority sites listed by EPA seven months ago. EPA public affairs officer Hagan Thompson says that $2.5 million is the largest sum of superfund money awarded in Region IV, the EPA region in which North Carolina is located. □

Venture weds computer and biotechnologies

International Plant Research Institute's (IPRI) founder and now former president, Martin A. Apple, is leaving to start a new venture, one that will try to wed the best of computer technology and biotechnology. This kind of management shuffling—some might call it upheaval, whereas others prefer the milder term transition—is another example of what's characterizing the young biotechnology industry (C&EN, March 29, page 10).

IPRI, located in San Carlos, Calif., has grown rapidly during the past few years. It's devoted to agricultural research and development, has assembled a multidisciplinary team of scientists for conducting such work, and currently is valued privately at more than $100 million, C&EN has learned. Management changes to accommodate this rapid growth apparently have been in the works since at least early this year.

The upshot is that Apple, who earned a reputation for outspokenness on IPRI's behalf, is leaving. A major shareholder in the company, he is expected to remain on the board of directors and also to serve the board as a consultant.

Apple plans to start up a new company, to be called EAN-TECH, which derives from an old English usage meaning to wean and to give birth to new lambs. The new company is intended to satisfy what Apple has called his persistent "itch to innovate." With seed money from Apple and a small group of private investors, EAN-TECH most assuredly will need to innovate to satisfy its purported mission of combining the world of computers with that of biotechnology. For example, the company will try to design improved and novel bioactive substances by relying partly on computer-guided design, much as is being attempted for the design of new drugs. Plans for the new company, which is to be staffed by a small group of researchers who can understand one another's disciplines, are being kept vague (if not secretive) to discourage would-be imitators. □

C&EN staff photo

Apple: an itch to innovate

Polyester shakeout stirs recovery hopes

There may be light at the end of the tunnel for the textile polyester filament industry, after all—and not the headlight of an oncoming train. The tunnel has been a long one for this important fiber, with a producer shakeout since the mid-1970s.

Producers have been cheered by the latest moves by Celanese in this business. Earlier this month, the company announced that as of August, it will close 200 million lb per year of polyester filament spinning capacity for partially oriented yarn. And last week, it took the relatively bold step—for the second largest U.S. supplier—of raising prices on partially oriented yarns 12 cents per lb, effective July 19. Celanese also announced that it would eliminate discounts on partially oriented yarns for the export market.

In general, polyester-filament producers were in agreement that something had to give in the business, which was beset by serious overcapacity. Capacity utilization had slumped to about 70% of nameplate capacity in the first quarter of 1982.

Celanese's shutting down 200 million lb of capacity—nearly half of the 450 million lb of filament capacity it has, by some estimates—will trim total industry capacity for textile polyester filament roughly 14%, to 1.25 billion lb per year, giving a sizable boost to effective capacity utilization. Du Pont remains the largest supplier, with an estimated 660 million lb per year of filament yarn capacity. After Celanese, the capacity falls off quickly, to about 110 million lb for American Enka, perhaps 105 million lb for American Hoechst, 90 million lb for Eastman Kodak, and 35 million to 40 million for Avtex.

Some industry sources contend that the pricing in polyester filament was in serious shape. Price discounting was heavy, even for branded fibers. A typical list price (in the U.S.)

Polyester filament has slumped in shipments . . .

Millions of lb	March 1982	April 1981	% change
Industrial	27.8	29.0	−4.1%
Low-denier industrial	1.9	2.9	−34.5
Textile	88.5	123.6	−28.4
TOTAL	118.2	155.5	−23.7%

. . . and in utilization of plant capacity

	1st-qtr 1982	3rd-qtr 1981	1st-qtr 1981
% of nameplate capacity	70%	93%	82%
% of effective capacity	74	99	87

was about $1.05 a lb, with discounted prices going as low as 85 cents a lb.

Other producers feel that the problem wasn't really a case of massive price erosion, as one puts it, but a normal "give and take" of small lots of fiber being discounted during slow times. The reason for the sluggishness, besides general U.S. economic conditions, is a slowdown in exports. Exports had been doing well because of major sales to China, both by U.S. producers and others throughout the world. But the Chinese recently curtailed their buying. Producers surmise that they bought more than they needed, so now they have to get inventories under control. Suppliers don't see any major resumption of sales to China until probably late this fall.

Ironically, although producers cheer Celanese's actions as positive for the immediate health of the industry, one spokesman takes a less sanguine long-term view: "When the market turns around—and it will—there will be demand but not enough capacity to really take care of it."

Other producers, however, feel that any shortages would be brief, particularly in the U.S., as suppliers shifted from export sales to domestic sales. Similarly, they say that on a worldwide basis, if demand comes roaring back, there may be some temporary shortages, but capacity would be added quickly. ☐

No cancer link found in formaldehyde study

An epidemiologic study of cancer mortality among Du Pont employees who had worked with formaldehyde has shown no excess of cancer deaths in comparison to other employees.

Du Pont medical director Bruce W. Karrh says that the results of the study are consistent with findings from other epidemiology studies and suggest that formaldehyde hasn't caused cancer in humans. Karrh further says that the results support the company's conclusion that airborne levels of 1-ppm time-weighted-average and a 2-ppm ceiling provide adequate employee protection.

Du Pont began the study in 1980. Earlier, in 1979, preliminary results of a long-term inhalation study at the Chemical Industry Institute of Toxicology, Research Triangle Park, N.C., had indicated that formaldehyde is a carcinogen in rats. At that point, three of 120 male rats exposed for 16 months to 15 ppm of formaldehyde for six hours per day five days per week had developed squamous cell carcinoma in nasal passages. This earlier study, incidentally, was a major factor in the recent controversial ban on use of urea-formaldehyde foam insulation in schools and homes (C&EN, March 29, page 34).

For their study, Du Pont epidemiologists analyzed cancer deaths from 1957 through 1979 at eight plants that make or use formaldehyde. Among all present and former employees during that period, 481 deaths were from cancer, including 142 who potentially were exposed to formaldehyde.

The data were analyzed by tumor site, latent period, duration of exposure, exposure level and frequency, cumulative exposure index, age and year of death, and year of first exposure. Adjustments were made to lung cancer deaths for cigarette smoking habits.

Analysis found that cancer mortality rates in the formaldehyde workers were no higher than those among workers not involved with formaldehyde. The study found no cases of nasal cancer and no excess of lung cancer.

Slight, but statistically nonsignificant, elevation in relative risks were noted in the study for prostatic and bladder cancers, Du Pont says. However, it adds, these elevations showed no indications of being related causally to formaldehyde and appeared to be due to chance. ☐

Gulf Resources proxy fight nears climax

In June, an infrequent—for the chemical industry—major proxy fight could end for control of Houston-based Gulf Resources & Chemical. This particular battle is rare indeed; the dissidents stand a chance of winning, from early evidence in the voting.

The vote took place at Gulf Resources' annual meeting May 11, but certification of the results has been delayed into June by court order. Gulf Resources has about 45% of its sales in lithium chemicals, industrial explosives, fertilizers, and salt.

In late May, the dissident group, headed by Alan E. Clore, an investor and British citizen, appeared to have received the larger share of votes cast, about 55% of nearly 6.3 million. Review, examination, and challenges of the proxies (voting rights given by shareholders to the two principals) have been going on at CT Corp., a Wilmington, Del., company specializing in corporate election inspections.

The dissident group, called Gulf Resources & Chemical Corp. Committee for New Management, with Clore as chairman, wants to restructure the company to get maximum value of the stock for stockholders. On why it is making such an effort, the group particularly cites rejection in February 1980 of an outside acquisition offer of $42.12 per share for the company's common stock. This offer was way above the market price then and now. In late May, Gulf Resources stock was selling at about $17 a share.

In August 1981, the current Gulf Resources management, headed by chairman Robert H. Allen, began shutting down its money-losing nonferrous metals mining, smelting, and refining operations. Low prices for lead, zinc, and silver had led to losses in these operations in a subsidiary, Bunker Hill Co.

As a result of the shutdown of Bunker Hill, Gulf Resources took a one-time loss of more than $90 million in 1981. Earnings from continuing operations were $12.5 million.

Whether any or all of the various parts of Gulf Resources will remain if the dissident group becomes the new management is unknown, according to a spokesman for the group. If the group does win, it says that it immediately will begin studies of the company's assets and consider strategies for redeployment. ☐

Supply problems cloud outlook for radioisotopes

Availability of separated stable isotopes, raw material for most radioisotopes, is being hampered by both equipment, budget problems

Stephen C. Stinson
C&EN, New York

The worldwide synthetic radioisotopes industry is expanding at an impressive pace. Radiopharmaceuticals sales will come to $130 million in the U.S. this year and about $200 million worldwide, growing 15% annually. Radiochemicals for research are a $40 million market in this country and $65 million worldwide, increasing 7% per year.

Medical research continues to develop new diagnostic techniques using radioisotopes hitherto unthought of. U.S. radioisotope production capacity is expanding vigorously, while government agencies of other countries are adding to present capacity or installing their first facilities.

But the cloud of a possible raw materials shortage hangs over all this prosperity. With the exception of transuranium elements, synthetic radioisotopes are produced by neutron irradiation or ion bombardment of separated stable isotopes. Of the 83 elements from hydrogen to bismuth, 20 are monoisotopic in nature, two are synthetic radioisotopes, and stable isotopes of 11 are available in relatively large amounts from distillation, diffusion, or chemical exchange plants. For the remaining 50 elements, the only reliable source of separated stable isotopes in the world is a bank of 30 electromagnetic separators called calutrons at Oak Ridge National Laboratory in Tennessee operated by Union Carbide for the Department of Energy.

The problem is that the calutrons were installed in 1943 and need an overhaul badly. Too, limited budgets, combined with a recent reassignment of trained workers to a second bank of calutrons to separate radioisotopes for weapons production have reduced stable isotopes separation to 50% of capacity. The result is that Oak Ridge is running behind in supplying demand. Of 240 stable isotopes of 50 elements, Oak Ridge is out of stock of 60, with no prospects of replenishing inventories of most of these for years.

The stable isotope supply situation has alarmed three communities of Oak Ridge customers—U.S. research scientists, U.S. radiopharmaceutical makers, and foreign customers of all kinds—who may come to blows over their mutually conflicting interests. Researchers use stable isotopes for their own sakes as tracers or in studies of nuclei. Collectively, they usually need to buy minute amounts of any and all of the 240 stable isotopes, or borrow them from the Oak Ridge research materials collection for nondestructive studies. Radiopharmaceuticals producers need kilogram amounts of half a dozen stable isotopes. Their needs take up 80% of current available calutron time.

Additional electromagnetic separation plants exist in the U.S.S.R. and Israel. The Soviets sell in the U.S. through Kolon Trading Co., New York City. A bank of calutrons thought to be located in Kharkov separates a wide variety of isotopes. Customers tell C&EN that quality is good and the price is right, but they fear disruptions in supply due to future possible political quarrels between the two governments. The Israelis occasionally offer a few isotopes in the U.S., separated using excess capacity on units used for research, but customers complain that prices are too high.

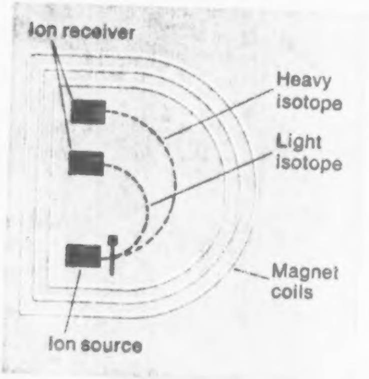
One solution would be for DOE simply to increase the budget for the Oak Ridge calutrons and recover the increase from sales. Oak Ridge isotopes section head Eugene Newman says such a move would enable him to restore adequate inventories of all isotopes and meet customer demands for many years. Other observers doubt DOE will take this simple way out and fear that present budgets actually will be cut. They note that government officials see the calutrons only as a cost, do not relate operating costs and sales revenues, and cannot budget for expenses in one year that will be recovered in future years.

The National Research Council's committee on chemical sciences brought representatives of Oak Ridge's research, clinical, and manufacturing customers together in February at a meeting sponsored by DOE and the National Institutes of Health. In a report published by NRC in mid-May, a panel of commercial customers indicated the possibility of forming a consortium to lease one calutron from Oak Ridge, supply capital to renovate it, send in their own crew to operate it, and use the output to supply their needs. The commercial panel also suggested that companies supply Oak Ridge with an annual list of their needs to schedule more orderly production. Many U.S. company representatives believe that Oak Ridge should adopt a policy of selling to foreign buyers only surpluses over and above U.S. firms' needs. But leasing a calutron to private users may be alien to DOE's philosophy. And rationing isotope sales could become an explosive political issue to foreign buyers, most of whom are government agencies.

Recommendations of three panels of research and clinical customers included a board representing all user communities to advise DOE on production scheduling and priority of inventory replenishment and increased funding for calutron operation. All four panels urged exploration of alternative methods of isotope enrichment of heavily used elements to take the load off the calutrons. Indeed, G. Sargent Janes, vice president for isotope research at Avco Everett Research Laboratory, Everett, Mass., says his company can adapt its technology for laser-induced photoionization of atoms of one isotope followed by electrostatic collection, to such heavily used isotopes. Janes estimates the project would take two to three years and cost $1 million for research and development and $2 million to build a pilot plant. And physics professors Mahadevan Krishman and Jay L. Hirshfield of Yale University, New Haven, Conn., described their technique of ionizing volatile compounds with an arc, followed by centrifugation of the plasma in a magnetic field. They estimate costs of one such unit at $1.4 million.

Such alternative methods, if realized, might be built only by DOE. The few million dollars needed to develop

Calutrons most versatile for isotope separations

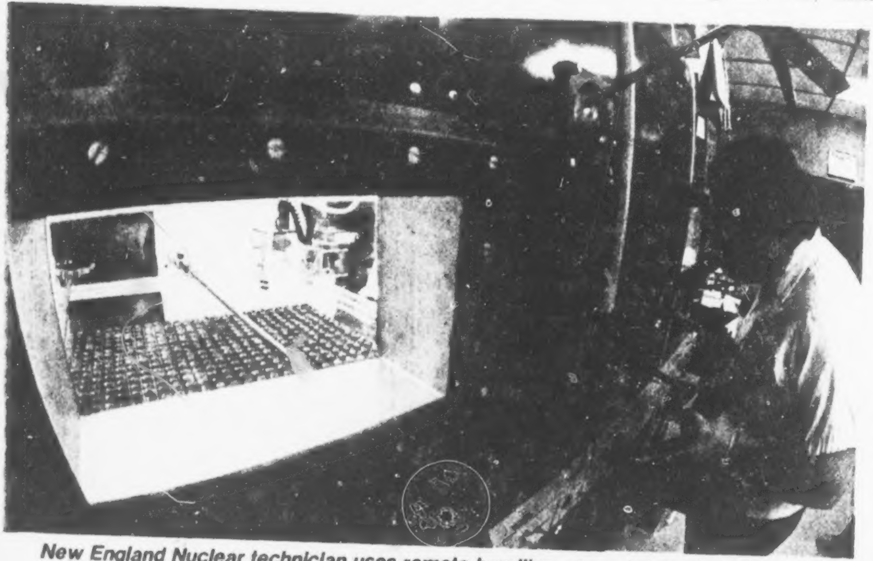


and install them may be too much for any one firm. Among radiopharmaceutical producers contacted by C&EN, only Marvin Stolberg, president of New England Nuclear, Boston, has considered such a project seriously, possibly by laser.

That there is any stable isotope supply problem at all is due largely to fruitfulness of radiopharmaceutical research, which has created a demand for cyclotron-produced radioisotopes in the past decade. Ten years ago, reactor-produced isotopes were the mainstay of nuclear medicine. Irradiation of an alloy of aluminum and enriched uranium-235 with neutrons, for example, produces molybdenum-99 and xenon-133 among the fission products. Xenon-133 is a beta-emitter with a 5.25-day half-life, used for imaging in lung ventilation studies. Molybdenum-99, nicknamed "fission moly," is fabricated into generators, where it decays by beta emission with a half-life of 66 hours to technetium-99m, which nuclear physicians elute from the generator. The m in the name of this isotope means metastable, which refers to the nuclear excited state in which this isotope is produced. When combined with various ligands, technetium-99m finds use in brain, liver, bone and kidney scans, as well as heart function studies.

Reactor-produced isotopes have not been replaced, but cyclotron-produced isotopes have joined them. Cyclotron-produced isotopes can be tailored rationally to concentrate in certain organs or abnormal tissue. Those with short half-lives can be chosen to minimize radiation doses. Neutron-deficient isotopes can be favored, because they often decay by a desirable electron capture process rather than by electron, positron, or alpha emission. Electron capture is the capture of a K-shell electron of the atom by a proton in the nucleus to form a neutron, with emission of characteristic gamma rays.

Of 1723 g of separated isotopes sold by Oak Ridge in fiscal 1980, the most recent year for which data are available, 708 g was thallium-203 and 118 g was zinc-68. Proton bombardment of thallium-203 yields lead-201 and three neutrons. Lead-201 decays by electron capture to thallium-201, which is isolated for heart studies. Thallium-201 concentrates in heart muscle, and failure to do so reveals locations of coronary artery blockage or dead tissue from a heart attack. The two are distinguishable, and surgeons can gauge success of operations to relieve arterial blockage. Zinc-68 produces gallium-67 by a similar reaction. Gallium-67 concentrates in abscesses and tumors. Other important radiopharmaceuticals are indium-111, produced from cadmium-112, to detect leakage of cerebrospinal fluid; and iodine-123, made from tellurium-124, for thyroid function tests.



New England Nuclear technician uses remote handling apparatus behind lead shielding to dilute a radiopharmaceutical to the desired concentration

For the future, the easily controllable chemistry of iodine may lead to increased demand for iodine-123, which has a half-life of only 13 hours, to label such compounds as fatty acids, which concentrate in the heart. These developments will lead to increased demand for separated tellurium-124. Mallinckrodt is developing gold-195m, whose half-life is a scant 30.6 seconds, to image blood but not heart muscle for measurement of pumping action and titration of drug doses against abnormal rhythms. The gold-195m will come from a generator containing mercury-195m. Mallinckrodt has not yet decided how to produce mercury-195m, but if the company chooses bombardment of gold-197, the natural abundance of that isotope is 100%.

Among U.S. radiopharmaceutical makers, New England Nuclear is the leader with estimated 1982 sales to that market of $45 million. Du Pont acquired the company in 1981. NEN was the first U.S. producer to put in its own cyclotron, in 1970 at Billerica, Mass. In addition to four cyclotrons now at Billerica, New England Nuclear will start up the first U.S. commercial linear accelerator there this fall. The 200-ft, 45-MeV, 5-milliampere accelerator, which cost $15 million, has the production capacity of eight 30-MeV cyclotrons, which would have cost $4 million to $6 million each.

The second-ranking producer is Mallinckrodt (acquired by Avon this year) with estimated 1982 sales of $35 million. The company started cyclotron production in Petten, the Netherlands, in 1978 upon acquiring the business and machines of Philips-Duphar for its Byk-Mallinckrodt joint venture with Byk-Gulden of Konstanz, West Germany. In 1980, Mallinckrodt signed an agreement with Medi Physics, Emeryville, Calif., to produce thallium-201 with the Medi Physics cyclotron in Chicago. That agreement ended early this year, after Mallinckrodt started up its own 30-MeV cyclotron in St. Louis. The company plans to turn on a second 42-MeV machine there this summer.

Medi Physics, which is a subsidiary of Hoffmann-LaRoche, is in third place with estimated 1982 radiopharmaceutical sales of $30 million to $35 million. The company started cyclotron production in 1971 and now has one in Emeryville, two in Chicago, and one in South Plainfield, N.J. Medi Physics dispersed its machines in this way to be as close as possible to customers of such very short-lived radioisotopes as iodine-123 (13 hours) and krypton-81m (13 seconds) for lung ventilation studies. The firm bought Union Carbide's Cintichem radiodiagnostics business, centered on a reactor at Tuxedo Park, N.Y., in 1981. Carbide kept the reactor to operate for Medi Physics, because U.S. law makes the Swiss parent ineligible to operate a reactor here. Carbide also sells such products as fission moly and xenon-133 to others.

The fourth major U.S. radiopharmaceuticals supplier is E. R. Squibb & Sons, Princeton, N.J., with estimated 1982 sales of $15 million to $20 million. The company does not produce radioisotopes, but sells kits that can be labeled with technetium-99m generators.

Besides the Union Carbide reactor at Tuxedo Park, the only other commercial source of reactor-produced isotopes in North America is Atomic Energy of Canada Ltd., which has two reactors at Chalk River, Ont. Customers can send targets to be irradiated to the University of Missouri, Rolla, as well.

In addition to target irradiation, AECL's reactor design allows use of cobalt control rods, which build up large amounts of cobalt-60 in use. Canadian exports of cobalt-60 to the U.S., expressed in curies, are growing at the rate of 33% annually for such uses as sterilization of medical supplies and fabrication of thickness gages. A curie is the amount of radioisotope that yields 3.7×10^{10} disintegrations per second.

From 1957 to 1978, General Electric's Vallecitos Nuclear Center, near Pleasanton and Sunol, Calif., produced 90% of U.S. reactor isotope needs. Shut down in 1978 because of the discovery of a seismic fault nearby, the reactor has not received approval for restarting.

AECL will begin marketing finished radiopharmaceuticals in Canada this July, according to Brian Armstrong, general manager of the new radiopharmaceuticals products group. This move will put the crown corporation into competition with Merck Frosst Canada, Montreal, and imports from New England Nuclear. AECL has no current plans to market in the U.S., Armstrong explains, because of heavy investment needed to secure New Drug Applications (NDAs) from the U.S. Food & Drug Administration, a U.S. sponsoring partner, and a distribution system here. The first products out in July will be technetium-99m generators and single-dose forms of xenon-133. By October, AECL will be selling thallium-201 and gallium-67, following installation of a 42-MeV cyclotron at the TRIUMF accelerator site at the University of British Columbia, Vancouver, in which AECL is a participant. AECL will depend on Oak Ridge for thallium-203 and zinc-68 raw materials, and has no plans to separate such isotopes itself.

Supply of separated isotopes of 11 lighter elements and the inert gases is plentiful. Some isotope markets here have attracted private firms. DOE's Savannah River plant, Aiken, S.C., operated by Du Pont, shut down its 100 ton-per-year heavy water plant in December 1981, but still produces tritium. Isotopes of lithium and boron are separated by Eagle-Picher Industries at Quapaw, Okla. DOE's Mound Facility, Miamisburg, Ohio, operated by Monsanto Research Corp., separates isotopes of chlorine, sulfur, and the inert gases. In 1979, two Mound employees, Roger Schwind and Vincent Avona left to form Isotec, Centerville, Ohio, which separates inert gas isotopes. The company will add carbon isotopes to its line in 1983. Because DOE's policy is not to compete with private firms, Mound has withdrawn from the rare-gas isotope market, except for sales to DOE and holders of DOE contracts and grants. Mound probably will get out of carbon isotopes sales to others than DOE in 1983. Carbon, oxygen, and nitrogen isotopes are separated at Los Alamos National Laboratory, operated by the University of California, and distributed through Mound.

The Savannah River heavy water plant, which could be restarted if needed, uses the Girdler sulfide process. Hydrogen sulfide percolates upwards past sieve and bubble cap trays in a series of columns against a downflow of water. Passage through four columns yields water with 4 to 5% deuterium. Vacuum distillation completes enrichment to greater than 99%.

Production methods and amounts of tritium at the Savannah River plant are classified. Reaction of lithium-6 with neutrons produces tritium and helium.

Eagle-Picher separates lithium isotopes by an exchange extraction of aqueous lithium hydroxide from lithium amalgam. Lithium-7 tends to concentrate in the amalgam. It is

U.S. radioisotope imports increase . . .

Year[a]	Cobalt-60 Quantity (1000 curies)	Cobalt-60 Value ($ million)	Other Quantity (1000 curies)	Other Value ($ million)	Total[b] Quantity (1000 curies)	Total[b] Value ($ million)
1981	8341	$6.4	217	$20.7	8558	$27.2
1980	6806	5.0	80	19.0	6886	24.0
1979	5893	3.9	84	16.2	5977	20.1
1978	3534	2.7	93	18.8	3627	21.9

. . . but export value remains much larger

Year[a]	Drugs[c] Quantity (1000 curies)	Drugs[c] Value ($ million)	Carbon-14 Quantity (1000 curies)	Carbon-14 Value ($ million)	Cobalt-60 Quantity (1000 curies)	Cobalt-60 Value ($ million)	Other Quantity (1000 curies)	Other Value ($ million)	Total[b] Quantity (1000 curies)	Total[b] Value ($ million)
1981	9.4	$36.2	0.2	$3.5	0.2	$1.1	44.0	$47.6	53.7	$88.4
1980	4.5	31.6	0.1	2.9	0.7	0.6	33.4	36.3	38.7	71.3
1979	14.0	27.4	0.1	2.2	5.0	0.4	35.9	28.3	55.0	54.5
1978	18.4	15.7	0.9	2.4	48.9	1.3	64.9	31.5	116.6	50.9

a Calendar year. b Sum may not equal totals because of rounding. c Includes cobalt-60 for medical uses. Source: Bureau of the Census

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Glass dominates U.S. soda ash use

Millions of tons	Soda ash
Glass	3.91
Glass container	2.77
Flat glass	0.65
Glass fiber	0.21
Other	0.28
Chemicals	1.32
Detergents	0.52
Pulp	0.25
Water treatment	0.25
Other	0.95
Exports	1.10
TOTAL	8.30

Source: FMC Corp.

as the 1980s began, and more is coming. In addition, technology development through solution mining of raw material trona ore could reduce mining and processing costs. At the same time, glass, the major use of soda ash, is threatened increasingly by plastics. These factors all will tend to lower the relative price for soda ash.

The upshot, Shamel forecasts, will be a growing differential in selling prices of these sodium oxide sources. He estimates that caustic soda prices will increase 2 to 3% annually in real dollars; soda ash prices will rise zero to 1%.

Other economic factors also influence conversion possibilities and are very site-specific. Among them, for example, are delivery prices for caustic soda and soda ash, volume of use, capital investment needed for conversion, and any associated operating costs differences.

Some conversion already has occurred, especially by producers of inorganic sodium compounds, such as detergent phosphates. As of the end of 1981, Shamel estimates that 400,000 tons of annual consumption of caustic soda has been converted to soda ash. He forecasts that by 1990 the conversion could reach 1.5 million tons of annual consumption. This quantity would be about 10% of his estimated 1990 capacity for caustic soda.

Shamel's view is shared, although with more conservative figures, by FMC, the largest soda ash producer. Conversion potential would reach 230,000 tons annually by 1986 as chlorine demand grows 1.0% per year and caustic 1.3%, estimated James T. Lowe, Charles W. Raleigh, and Andrew F. Zeller of FMC at the Chemical Marketing Research Association's meeting in New York City earlier this month.

Besides inorganic compounds, other areas of potential conversion foreseen by Shamel are neutralization of process and waste streams, scrubbing of process and off-gases, water treatment, pulp and paper manufacture, and alumina production.

Not all uses of caustic soda may be practical to convert to soda ash, Shamel adds. For example, the chemical reaction involved may require caustic soda for thermodynamic reasons. Or soda ash may not provide a high enough pH. Evolution of carbon dioxide during a neutralization with soda ash could be undesirable. And the carbonate ion from soda ash could cause unwanted side reactions or other process complications.

In neutralization uses—next to detergent phosphates the most likely area for conversion—one of the major drawbacks will be relatively high capital investment. Such investment would go largely for equipment to dissolve soda ash, since many current neutralization sites use liquid caustic soda. Liquid soda ash, however, recently has become available commercially.

Pulp and paper manufacture are the next most likely candidates for conversion. Rough economics might be like this: At a southern paper mill, caustic would be delivered for $280 per ton for an annual use of 5000 tons. Soda ash might be delivered for $140 per ton, or $186 per ton of caustic equivalent. An investment of $120,000 might be needed for receiving, transferring, and dissolving equipment.

The operating penalty with soda ash would be $30 per ton converted. Material savings with soda ash would be $220,000 a year (5000 times $230 minus $186). Net variable cost savings with soda ash would be $70,000 a year ($220,000 minus 5000 times $30). The payout time on the investment would be about 1.7 years ($120,000/$70,000).

For some uses, soda ash is currently an economic substitute for caustic soda. But conversion is held back by inertia, a dislike by users for solids handling, or a belief that high caustic prices are temporary, Shamel says. However, he predicts that economic incentives are increasing and will bring more and more conversion as the 1980s proceed. ☐

Mobil to offer new monomer for plastics

Is the world ready for a new styrene? And if it is, for what applications? That's what Mobil Chemical is asking as it nears startup, this fall, of a plant to make *p*-methylstyrene, the hottest "new" product to surface in the highly competitive world of monomers for plastics. Mobil will produce its *p*-methylstyrene in a plant owned jointly with American Hoechst, in Baton Rouge (C&EN, May 24, page 15); capacity is set at 35 million lb per year.

Methylstyrene actually has been around for a long time, although it usually is called vinyltoluene—an umbrella name for a combination of the meta- and para-isomers. Dow Chemical, for example, has been producing and marketing vinyltoluene since the 1950s, and now has capacity at Midland, Mich., of 70 million to 90 million lb per year. And last year, Cosden Oil & Chemical began commercial production of vinyltoluene in Big Spring, Tex., with capacity of roughly 40 million lb per year.

Total worldwide market demand for vinyltoluene is estimated at about 100 million lb per year, in specialty applications. That's a tiny market compared to the 6.61 billion lb of styrene produced in the U.S. alone last year. Up to now, however, potential markets for methylstyrene have been held back by the difficulty of obtaining the isomer desired.

The key to Mobil's new process is its proprietary zeolite alkylation catalysts, which control formation of the methylstyrene so closely that the process yields as much as 97% para-isomer. The company "has not yet established a commercial licensing policy," a spokesman says.

With a 35 million lb-per-year plant, Mobil and Hoechst are just dipping their toes into the water. Some industry observers feel that if marketers are going to make a serious dent in the styrene business, even with a monomer that promises better polymer performance, as *p*-methylstyrene does, it will take a major effort. That's the assessment, for example, of John D. DeWitt, president of Houston consultants DeWitt & Co., who predicts that if someone takes "the enormous risk of building a world-scale poly-*p*-methylstyrene unit," to bring economies of scale into the process, poly-*p*-methylstyrene can capture as much as 400 million lb of the total polystyrene market by late in this decade. ☐

action in the May 20 *Congressional Record*. There he said that "existing unserviceable lethal chemical artillery shells are not to be renovated and are to be demilitarized [neutralized] when practicable." Excluded from the one-to-one replacement scheme are those munitions "designated 'unserviceable' in the Army's June 1981 report on the chemical stockpile," he explained.

The Defense authorization bill now moves to the House. The House Armed Services Committee has not announced floor action, but the bill is expected to come up for a vote within the next six weeks. A Hart-type amendment deleting chemical weapons production funds is expected to be offered by Rep. Toby Moffett (D.-Conn.) and others. Like the Hart amendment, it is not expected to pass. The final Senate version on chemical weapons, in fact, is expected to prevail.

The next, perhaps significant, skirmish will be at the appropriations level. There, Hatfield will manage the bill, and bring to that effort his abhorrence of chemical warfare which will inflict, he says, greater casualties on civilians than on military personnel in protective gear.

Hatfield will be supported by those who for other reasons wish to see a ban on these weapons. One is Sen. Dennis DeConcini (D.-Ariz.), who supports a strong military, but who has "no reason to believe that the actual production of binary chemical weapons will do any more to stop the Soviets from using these weapons or to bring them to the bargaining table in a frame of mind which would lead to the abolition of these weapons than would the threat that the U.S. is in a position to produce such weapons without delay." DeConcini already has supported a Senate resolution calling on the Administration to reinitiate chemical arms talks with the Soviets. □

Waste treatment firms handling less volume

A survey conducted for the Environmental Protection Agency of major hazardous waste management firms shows that, although they managed to increase revenues 20% in 1981 over the previous year, the volume of wastes handled actually declined. And though none of the surveyed firms' facilities were closed completely during 1981, several had certain portions of their operations, such as landfills, closed because of public opposition or compliance problems. Some other facilities required major capital expenditures to comply with federal or state regulatory requirements but were able to remain open.

The nine firms surveyed by Booz, Allen & Hamilton Inc.'s energy and environment division account for more than 50% of all commercial waste disposal and treatment. The firms are: Browning-Ferris Industries, CECOS International, Chem-Clear, Chemical Waste Management, Conversion Systems, IT Corp., Rollins Environmental Services, SCA Chemical Services, and US Ecology. The new survey is an update of one done in 1980.

In 1980 the nine firms operated 36 of the 127 identified hazardous waste facilities; in 1981 that number was up to 46. But of the 10 additional facilities only three belonging to Chem-Clear were totally new. The others represent acquisitions of existing firms. Nevertheless, the nine firms increased their permitted landfill capacity 46% and their chemical treatment capacity 18%. But the report notes these capacity increases do little to diminish potential regional capacity shortages identified in the 1980 survey because not only were many of the capacity additions transfers of ownership but most of the others represent expansion at existing sites in regions that had the greatest capacity to begin with. Many of the firms are continuing to pursue new landfill sites but report that public opposition remains as intense as ever.

Despite the increased capacity the volume of wastes treated by the nine firms actually declined from 3.7 million wet metric tons (WMT) in 1980 to 3.6 million WMT in 1981. The report attributes this reduction to a number of factors. One is the recession. Many of the industries hardest hit, such as auto, steel, and the metal fabricating industries, also are major users of commercial treatment and disposal, but now are generating less waste.

Another factor is the huge price increases—at certain facilities increases of more than 50%—that occurred in 1979 and 1980 for hazardous waste management services and made many waste-reducing options that were only marginally economic in 1979 clearly economic in 1981. Generators now are more careful, the report points out, to segregate hazardous from nonhazardous waste for disposal or are reducing waste generation by raw material substitutions. In addition, some of the major generating industries have been successful in having some large-volume waste streams, such as certain paint sludges and pickle liquor sludges, taken off the hazardous waste list.

One additional factor cited by the report is that many large chemical companies have reduced their reliance on off-site facilities substantially over the past several years and are striving for 100% internal waste management to minimize liability problems, maintain production controls, and avoid off-site disposal costs.

And these costs did go up in 1981 with price increases averaging 15%. But, as the report points out, these increases are well below those of 1979 and 1980 that virtually doubled the cost of off-site hazardous waste disposal and treatment.

What this new study indicates, says Alan Farkas, a Booz, Allen vice president who directs environmental studies, "is that if volumes received do not strongly recover after the recession ends, waste management firms will have to offer a broader range of services to sustain growth and earnings." □

Firms increase capacity, but have less waste to handle

	Capacity[a]			Volume received[a]		
Type of waste management	1981	1980	% change	1981	1980	% change
Landfill	37,372	25,672	46%	1965	2182	−10%
Land treatment/solar evaporation	1,400	1,447	−3	282	300	−6
Chemical treatment	1,305	1,105	18	734	544	35
Deep-well injection	1,095	1,095	0	475	475	0
Resource recovery	341	341	0	83	83	0
Incineration	102	102	0	80	85	−6
TOTAL	**41,615**	**29,762**	**40%**	**3610**	**3669**	**−1%**

a Thousands of wet metric tons. **Source:** Booz, Allen & Hamilton Inc.

Chemical & Engineering NEWS

A1250-1 6/8/82

U.S. chemical profitability continues to plunge Page 17

Superfund

EPA gears up to stop waste disasters
Page 10

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Chemical & Engineering NEWS

Cover: Kin-Buc landfill in Edison, N.J., hit by fire in 1978, contains 70 million gal of chemical wastes. EPA has spent $1.1 million from Superfund for emergency cleanup at the site and committed $2.8 million more for remedial work

4 Letters

Concentrates

16 Business
20 Government
24 Science/Technology

The Departments

37 New Products
43 ACS Comment
50 People
58 Meetings
60 Newscripts

News of the Week

- ***Chemical industry will continue its slow pace*** *through the remainder of 1982, newly elected CMA officers say.* ***Page 6***
- ***Sohio will purchase Pfaudler*** *process equipment business from Sybron.* ***Page 7***
- ***Changes in the Clean Air Act*** *to allow an increase in sulfur emissions will affect health adversely, study claims.* ***Page 7***
- ***Monsanto and Washington University*** *launch biomedical research program focusing on peptides and proteins.* ***Page 7***
- ***OSHA wants to drop 194 rules*** *it considers unenforceable.* ***Page 8***
- ***Soviet chemist Tatyana Lozansky*** *begins the fifth week of her hunger strike to gain permission to emigrate.* ***Page 8***

News Focus

- ***Superfund's progress comes under fire*** *from its critics; EPA defends charges of foot-dragging.* ***Page 10***

Business

- ***Specialty chemical companies' profitability*** *topped that of basic chemical firms, but all profitability measures fell.* ***Page 17***

Government

- ***House rejects 1983 budget*** *resolutions after heated debate.* ***Page 22***

Education

- ***"Discovery learning"*** *describes experimental introductory lab course at SUNY's Cortland College.* ***Page 29***
- ***Refresher courses*** *in analytical chemistry offered at University of Florida.* ***Page 32***
- ***Ph.D. program for careers in industry*** *set up at University of Texas.* ***Page 32***

Technology

- ***Thin-film spreading agents*** *increase oil production at nominal cost.* ***Page 38***

Science

- ***Authentic formaldehyde semicarbazone*** *made by mixing organic solutions of diazomethane and azodicarbonamide.* ***Page 39***
- ***Contractors to synthesize*** *organic and inorganic compounds sought by NCI.* ***Page 39***

Books

- ***Roger Adams*** *was an academic scientist at ease in the world of industry.* ***Page 41***

ACS News

- ***Improving reliability of chemical data*** *used for public purposes is subject of ACS subcommittee report.* ***Page 44***
- ***Society honors*** *those who have attained 50 years of membership.* ***Page 49***

Specialty firms top chemical profitability

Most specialty chemical firms remained more profitable than basic chemical firms in 1981, as all profitability measures continued to fall

William J. Storck
C&EN, New York

Specialty chemical firms' profitability generally declined last year, but they continued to dominate C&EN's rankings of profitability measures among U.S. chemical companies.

However, there are some changes in the profitability lineup for 1981. No longer do the small mineral and fertilizer companies head up all of the rankings. For 1981 only one, Freeport-McMoRan, ran first and this was only in profit margin. The other three profitability measures—return on assets, return on investment, and return on stockholders' equity—were led by companies selling high-value-added specialty chemicals. Thus, the specialty chemical companies continued to enjoy the benefits of the high rates of return on their products. These high returns were due primarily to the high-value-added nature of those products.

However, the fertilizer and mineral dominated companies seem to have come to the end of one of the normal booms in their highly cyclical business. Thus, with fertilizer capacity use rates in the low 60% range because of lack of demand, fertilizer producers are losing profitability fast.

As a result, in terms of overall profitability, Freeport-McMoRan dropped from first place in 1980 (C&EN, June 1, 1981, page 8), to third place in 1981, behind Nalco Chemical and International Flavors & Fragrances, two specialty chemical companies.

Nalco led in two of the profitability measures—return on assets and return on equity. Its return on assets in 1981 was 17.4%, the same as in 1980. And its return on equity was 24.2%, up from 23.6% in 1980. Nalco came in second in return on investment at 14.5%, the same percentage as in 1980. The year before, however, the company had been fifth in return on investment.

The top companies in overall profitability

1 Nalco Chemical
2 International Flavors
3 Freeport-McMoRan
4 Lubrizol
5 Petrolite
6 Chemed
7 Great Lakes Chemical
8 First Mississippi
9 International Minerals
10 National Distillers

The 1981 leader in return on investment was Chemed at 15.1%. It was not included in the 1980 rankings, because much of its results were accounted for within W. R. Grace, which owned a big chunk of the Cincinnati-based company.

And Nalco, which did so well overall, was third in profit margin at 12.2%, up from eighth place in the

Profit margins at U.S. chemical companies fell to 5.6% in 1981

Rank[a] 1981	Rank[a] 1980		Profit margin[b] 1981	Profit margin[b] 1980
1	2	**Freeport-McMoRan**	19.1%	22.2%
2	5	**International Flavors**	14.7	14.1
3	8	**Nalco Chemical**	12.2	11.7
4	3	**Great Lakes Chemical**	11.7	14.9
5	7	**Lubrizol**	10.2	12.1
6	c	**Chemed**	10.0	8.0
7	9	**Petrolite**	9.4	9.8
8	16	**Stauffer Chemical**	8.7	7.2
9	11	**First Mississippi**	8.3	8.6
10	12	**Air Products**	8.0	8.1
11	12	**International Minerals**	7.7	8.1
12	16	**Liquid Air**	7.4	7.2
13	c	**National Distillers**	6.7	5.4
14	30	**Monsanto**	6.4	3.9
14	18	**Union Carbide**	6.4	7.0
16	20	**PPG Industries**	6.3	6.6
17	26	**W. R. Grace**	5.5	4.7
18	23	**Allied**	5.4	5.2
18	27	**American Cyanamid**	5.4	4.6
20	25	**Ethyl**	5.2	5.1

Rank[a] 1981	Rank[a] 1980		Profit margin[b] 1980	Profit margin[b] 1981
20	c	**FMC**	5.2%	4.1%
22	27	**Thiokol**	5.1	4.6
23	27	**Hercules**	5.0	4.6
23	19	**Williams Cos.**	5.0	6.7
25	6	**Loctite**	4.9	13.0
25	22	**Rohm & Haas**	4.9	5.4
27	15	**Dow Chemical**	4.8	7.6
28	31	**Essex Chemical**	4.7	3.6
29	38	**Olin**	4.6	1.8
30	c	**H. B. Fuller**	4.1	3.3
31	31	**Celanese**	3.8	3.6
32	36	**Crompton & Knowles**	3.5	3.2
32	31	**Pennwalt**	3.5	3.6
34	c	**Philip A. Hunt Chemical**	3.4	3.8
35	35	**Stepan Chemical**	3.2	3.4
36	34	**Witco Chemical**	3.0	3.5
37	37	**B. F. Goodrich**	2.9	2.0
38	38	**Reichhold Chemicals**	1.8	1.8
39	40	**Akzona**	1.0	0.5
40	c	**GAF**	def	1.5
		AVERAGE[d]	**5.6%**	**6.1%**

a Ranking for 1980 is as it appeared in previous survey (C&EN, June 1, 1981, page 8). b After-tax income as a percentage of sales; 1980 figures are not restated. c Company did not appear in previous survey. d Average for 1980 is for companies listed in previous survey. def = deficit.

Return on investment declined to 4.8%

Rank[a]			Return on investment[b]	
1981	1980		1981	1980
1	c	Chemed	15.1%	12.9%
2	5	Nalco Chemical	14.5	14.5
3	6	International Flavors	13.1	13.2
4	4	Lubrizol	11.5	14.9
5	9	Petrolite	11.0	11.0
6	2	Freeport-McMoRan	8.8	15.6
7	8	Great Lakes Chemical	8.5	12.7
8	c	H. B. Fuller	7.9	6.0
9	12	First Mississippi	7.8	8.2
10	c	National Distillers	7.7	6.4
11	17	W. R. Grace	7.2	5.6
12	14	Thiokol	6.8	6.1
13	19	Essex Chemical	6.6	5.3
14	13	International Minerals	6.1	6.4
15	28	Stauffer Chemical	5.8	4.7
16	26	Crompton & Knowles	5.7	4.9
16	3	Loctite	5.7	15.5
18	16	Ethyl	5.5	5.8
19	c	FMC	5.3	4.3
19	19	PPG Industries	5.3	5.3
21	21	Liquid Air	5.2%	5.2%
22	36	Monsanto	5.1	3.0
23	33	Allied	5.0	3.7
24	31	American Cyanamid	4.8	4.1
24	29	Hercules	4.8	4.3
26	26	Air Products	4.7	4.9
26	25	Rohm & Haas	4.7	5.0
26	21	Union Carbide	4.7	5.2
29	21	Witco Chemical	4.3	5.2
30	39	Olin	3.9	1.5
31	c	Philip A. Hunt Chemical	3.7	4.2
31	32	Pennwalt	3.7	4.0
33	17	Dow Chemical	3.6	5.6
34	21	Williams Cos.	3.5	5.2
35	34	Stepan Chemical	3.4	3.6
36	35	Reichhold Chemicals	3.3	3.1
37	37	Celanese	3.1	2.8
38	38	B. F. Goodrich	2.7	2.2
39	40	Akzona	0.9	0.4
40	c	GAF	def	1.3
		AVERAGE[d]	4.8%	5.0%

a Ranking for 1980 is as it appeared in previous survey (C&EN, June 1, 1981, page 8). **b** After-tax income as a percentage of current assets plus gross plant; 1980 figures are not restated. **c** Company did not appear in previous survey. **d** Average for 1980 is for companies listed in previous survey. **def** = deficit.

rankings for 1980 when its profit margin was 11.7%.

In 1981 rankings, profit margins (after-tax income as a percentage of sales) averaged 5.6%, compared with an average of 6.1% for the 40 companies surveyed for 1980. At the same time, return on investment (after-tax income as a percentage of current assets plus gross plant) declined to an average of 4.8% from 5.0% in 1980. Return on assets (after-tax income as a percentage of total assets) dropped to 6.2% last year from an average of 6.9% in 1980. And return on equity (after-tax income as a percentage of total year-end stockholders' equity) fell to 13.4% in 1981 from 14.5% the year before.

All of the balance sheet percentages—return on assets, investment,

Return on assets was 6.2% last year

Rank[a]			Return on assets[b]	
1981	1980		1981	1980
1	2	Nalco Chemical	17.4%	17.4%
2	6	International Flavors	15.3	15.2
3	9	Petrolite	14.1	14.2
4	3	Lubrizol	13.7	17.1
5	c	Chemed	10.9	12.5
6	4	Freeport-McMoRan	10.8	16.5
7	5	Great Lakes Chemical	10.6	16.0
8	12	First Mississippi	9.3	9.0
9	c	H. B. Fuller	8.6	6.6
10	c	National Distillers	8.0	6.6
11	20	Thiokol	7.9	7.0
12	13	International Minerals	7.8	7.9
13	27	Essex Chemical	7.6	6.1
14	29	Stauffer Chemical	7.4	5.8
15	35	Monsanto	7.3	4.4
16	16	Ethyl	7.2	7.4
16	24	W. R. Grace	7.2	6.5
18	16	PPG Industries	7.1	7.4
19	14	Rohm & Haas	6.9	7.6
20	28	Hercules	6.8	6.0
21	22	Air Products	6.7%	6.6%
22	26	Allied	6.5	6.4
22	22	Liquid Air	6.5	6.6
24	31	American Cyanamid	6.4	5.5
24	c	FMC	6.4	5.5
26	18	Union Carbide	6.2	7.2
27	32	Crompton & Knowles	6.0	5.2
28	7	Loctite	5.7	14.4
28	39	Olin	5.7	2.2
30	24	Witco Chemical	5.3	6.5
31	34	Celanese	4.8	4.6
32	32	Pennwalt	4.7	5.2
33	21	Dow Chemical	4.5	6.9
34	c	Philip A. Hunt Chemical	4.3	5.1
35	37	Reichhold Chemicals	4.2	3.8
36	29	Williams Cos.	4.0	5.8
37	36	Stepan Chemical	3.7	3.9
38	38	B. F. Goodrich	3.4	2.8
39	40	Akzona	1.4	0.6
40	c	GAF	def	1.5
		AVERAGE[d]	6.2%	6.9%

a Ranking for 1980 is as it appeared in previous survey (C&EN, June 1, 1981, page 8). **b** After-tax income as a percentage of total assets; 1980 figures are not restated. **c** Company did not appear in previous survey. **d** Average for 1980 is for companies listed in previous survey. **def** = deficit.

Return on stockholders' equity dropped to 13.4%

Rank[a]			Return on equity[b]	
1981	1980		1981	1980
1	5	**Nalco Chemical**	24.2%	23.6%
2	12	**Essex Chemical**	23.8	18.3
3	1	**Freeport-McMoRan**	22.5	29.6
4	11	**First Mississippi**	21.5	18.6
5	8	**Petrolite**	21.4	22.2
6	10	**International Flavors**	20.0	20.0
7	2	**Lubrizol**	19.7	24.6
8	15	**Allied**	18.3	17.4
9	c	**H. B. Fuller**	17.9	15.0
10	18	**W. R. Grace**	17.5	15.8
11	9	**Great Lakes Chemical**	16.5	20.3
12	14	**Air Products**	16.3	17.9
13	16	**International Minerals**	15.8	16.6
14	24	**Thiokol**	14.7	13.6
15	28	**Stauffer Chemical**	14.6	13.0
16	c	**Chemed**	13.8	17.5
17	c	**FMC**	13.6	11.5
17	c	**National Distillers**	13.6	11.7
19	37	**Monsanto**	13.4	9.1
20	30	**Hercules**	13.0	11.3
20	23	**PPG Industries**	13.0%	13.9%
20	19	**Witco Chemical**	13.0	15.4
23	31	**American Cyanamid**	12.9	11.1
24	25	**Ethyl**	12.6	13.5
25	26	**Rohm & Haas**	12.3	13.3
25	20	**Union Carbide**	12.3	14.6
27	27	**Liquid Air**	12.2	13.2
28	35	**Stepan Chemical**	12.1	10.7
29	31	**Celanese**	11.7	11.1
29	39	**Olin**	11.7	4.5
31	33	**Crompton & Knowles**	11.5	11.0
31	13	**Dow Chemical**	11.5	18.1
33	36	**Reichhold Chemicals**	9.8	9.3
34	21	**Williams Cos.**	9.6	14.4
35	33	**Pennwalt**	9.5	11.0
36	7	**Loctite**	8.6	22.6
37	38	**B. F. Goodrich**	8.4	6.5
38	c	**Philip A. Hunt Chemical**	6.7	6.9
39	40	**Akzona**	3.6	1.5
40	c	**GAF**	def	8.4
		AVERAGE[d]	**13.4%**	**14.5%**

a Ranking for 1980 is as it appeared in previous survey (C&EN, June 1, 1981, page 8). **b** After-tax income as a percentage of year-end stockholders' equity; 1980 figures are not restated. **c** Company did not appear in previous survey. **d** Average for 1980 is for companies listed in previous survey. **def** = deficit.

and equity—are figured on a year-end basis. This gives a more conservative ratio than some companies' figures, which are based on average balance sheet data for the year.

Although in the main the specialty companies performed well last year, it was not the case for all of them. For example, Loctite, the Connecticut-based adhesives manufacturer, came in for some hard times. Loctite's profit margin fell to 25th place (with 4.9%) in 1981 from sixth place (with 13.0%) in 1980. Its return on assets in 1981 was 5.7%, compared with 14.4% in 1980, sending it to 28th place from seventh. Return on investment for the company in 1981 was 5.7%, down from 15.5% in 1980, dropping it to the 16th slot from third. And return on stockholders' equity fell to 8.6% from 22.6% the year before, sending it down to 36th place from seventh in the previous ranking.

One of the best performances in terms of rankings was by one of the larger companies—Stauffer Chemical. During 1981 Stauffer managed to pull itself up smartly in all categories. Its profit margin increased to 8.7% in 1981 from 7.2% in 1980, bringing it up to eighth place from 16th the year before. Its return on assets increased to 7.4% in 1981 from 5.8% in 1980, sending it up to 14th place from 29th. Its return on investment improved to 5.8% from 4.7% in 1980, raising it to 15th from 28th. And return on equity was 14.6%, compared with 13.0% the year before, raising it to 15th from 28th.

In general, although the overall averages were falling, the number of companies with rising or falling profitability ratios was almost equal. In profit margins, 21 companies improved, and 18 companies declined from the year before. In return on assets, 20 were up and 19 were down. Return on investment split evenly with 18 improving and the same number declining. In return on equity, 20 had higher ratios, and 19 were down. □

About C&EN's profitability rankings

C&EN's rankings of companies by profitability are based on the 40 largest U.S. chemical companies, using nonrestated data.

Thus, the 1981 ratios are compared with 1980 ratios derived from data published at the end of that year and not restated data as published in 1981 annual reports for 1980.

Also, the average ratios appearing at the end of each table are for the companies that appear on the list for the respective years. In other words, the 1981 average is for the companies on the list this year, and the 1980 average is for the companies that appeared on the list last year (C&EN, June 1, 1981, page 8).

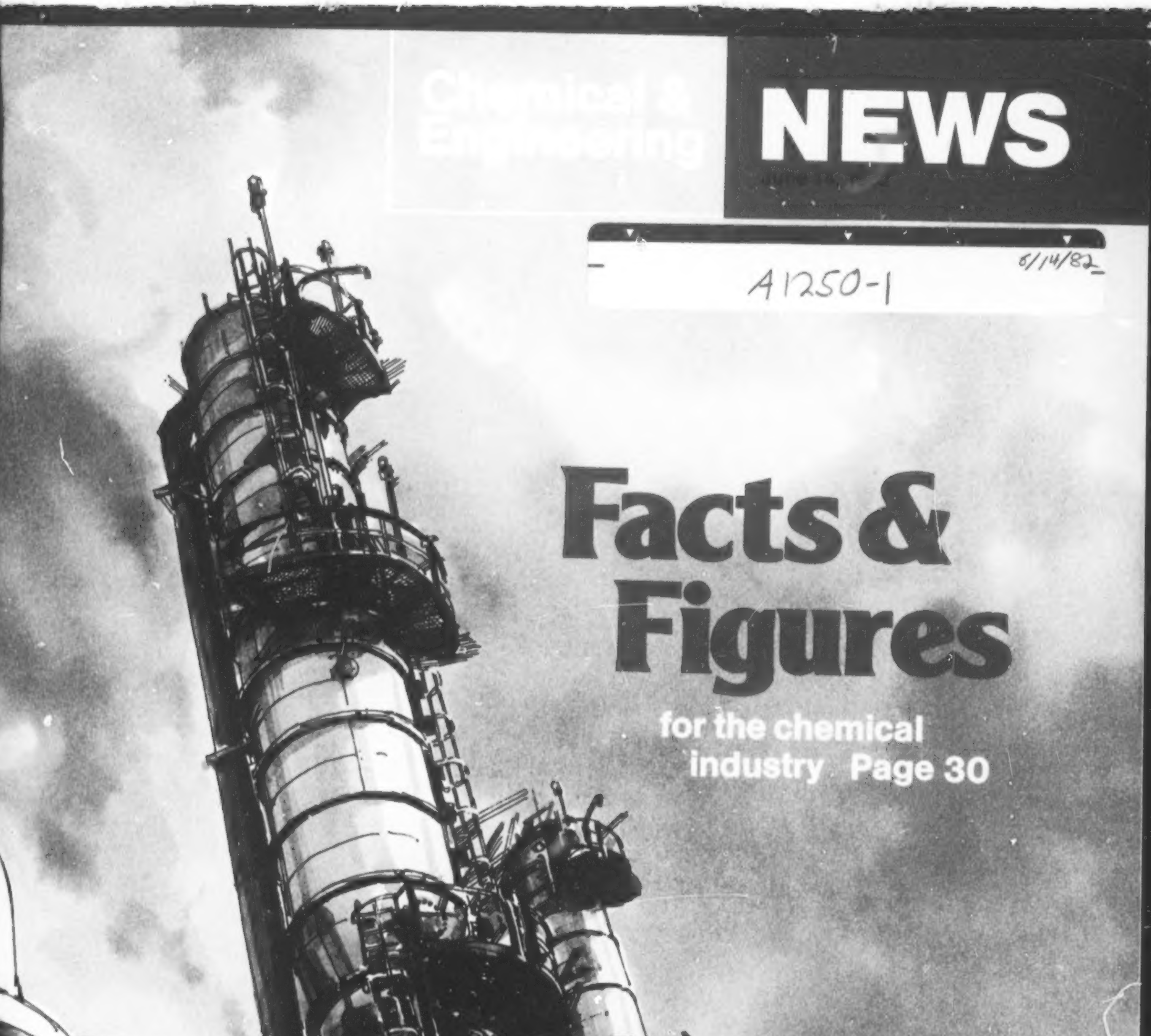
To be considered a chemical company for inclusion on the list, a firm must have at least 40% of its sales in chemicals, with the chemical segment of the company making up the greatest part.

This year, there are six new companies on the list, and six others have been dropped. Those that are not on the list this year and that appeared last year include Du Pont and Diamond Shamrock, which had a change in the basic sales structure; Texasgulf and Mallinckrodt, which have been acquired by other firms; and Beker Industries and Lawter International. The companies new to the list this year are Chemed, FMC, National Distillers & Chemical, H. B. Fuller, Philip A. Hunt Chemical, and GAF.

The six new companies appear on the list as not having been ranked in 1980, and the companies that have been dropped for 1981 still retain their 1980 rankings, thus influencing the rank of other companies on the table. For instance, since Texasgulf was ranked first in profit margin in 1980 and Freeport-McMoRan was second, Freeport retains its number two 1980 ranking and does not move up to number one simply because Texasgulf is no longer included for 1981.

Chemical & Engineering
NEWS
June 14, 1982

A1250-1 6/14/82



Facts & Figures

for the chemical industry Page 30

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Chemical & Engineering NEWS

5 Letters

Concentrates
10 Business
16 Government
19 Science/Technology

The Departments
84 ACS Comment
94 People
96 Newscripts

News of the Week

- ***Management control of Gulf Resources & Chemical*** *has been won by a group of dissident stockholders who plan to restructure the company.* ***Page 6***
- ***Soviet Union denies use of chemical warfare*** *in Southest Asia, charges toxins come from U.S. herbicide use in Vietnam.* ***Page 7***
- ***Employment of female scientists*** *and engineers rose 32% between 1974 and 1978, that of minorities 25%.* ***Page 7***
- ***FDA will require warning label*** *on aspirin-containing products, citing a link between aspirin use in children and development of Reye's syndrome.* ***Page 7***
- ***John C. Slaughter*** *leaves NSF directorship to become chancellor of the University of Maryland.* ***Page 8***
- ***Kuwaitis' share of stock*** *in West Germany's Hoechst is only 18%, not the 25% that was rumored earlier.* ***Page 8***

Business

- ***Iodine is suffering*** *from low industrial demand and selling of stockpiled product from government inventories but expected future needs may find supply short.* ***Page 12***

International

- ***Canadian methanol capacity*** *is far ahead of demand, leading Celanese Canada to compete with propane and compressed natural gas for the alternate fuels market.* ***Page 14***

Government

- ***Personnel layoffs at the national labs,*** *prompted by proposed big cuts in Department of Energy budget, mean loss of both expertise and continuity of programs.* ***Page 17***

Science

- ***New research on photosynthesis*** *provides insights on the mechanism of initial critical electron-transfer reactions.* ***Page 21***
- ***Funding for cancer researchers*** *in universities and private labs sought from foundations and companies to offset declining federal support.* ***Page 25***

Education

- ***New graduate program*** *trains chemistry students for work in industry; Doctor of Chemistry degree will be awarded to chemists completing the program.* ***Page 28***

Facts & Figures

1981 was a disappointing year *for the chemical industry both in the U.S. and abroad; earlier predictions of an end to recession proved overoptimistic.* ***Page 31***

Books

- ***Two books discuss evolution***—one promoting punctuated equilibria, the other recounting work with fossils. ***Page 82***

Letters

More on science education

SIR: In response to the story by Michael Heylin that appeared in C&EN, May 24, page 39, regarding high school science education, may I suggest that the problems of scientific literacy in the U.S. may be attacked (and solved) by the application of the following principles? They might be referred to as the 21st century version of the "three Rs"; because of current errors in societal thinking, we, as a nation, now have "five Rs."

1. RESTORE classroom discipline.
2. RETURN to the concept that formal education is a necessity and need not be fun and games.
3. REVISE teaching licensure requirements so that formal undergraduate preparation in the area to be taught (i.e., mathematics, sciences, etc.) becomes the dominant requirement, rather than courses in lesson plan preparation, educational psychology, and group dynamics.
4. REQUIRE six semesters of mathematics and six semesters of science for *all* secondary school students.
5. REJECT the idea that everyone must be identical (equal) in every aspect and accept the idea that individuals have qualitatively and quantitatively different talents and abilities.

Unless we, as a nation, are willing to accept these principles, any and all efforts of legislatures, conferences of experts, and appropriations of money will be merely empty gestures.

Roger P. Maickel

Lafayette, Ind.

SIR: How long do we have to relive history before we learn to remember some of it?! The prestigious speakers at the recent National Academy of Sciences convocation on science education (C&EN, May 24, page 39) remind one of the committee examining a camel . . . .

Fortunately, all agree that scientific competence of the public is a survival characteristic for cultural success, and we are dangerously close to becoming an endangered culture. However, cheap shots at past science education programs, such as the National Science Foundation's (the Reagan Administration's observation that they were a failure), ignore the fact that those programs fell short (if indeed they *did* fall short) only in that they were unable to make enough inroads on the entrenched pedagogic bureaucracy that was established through two centuries of decentralized, locally controlled education. Leadership has long been available in the scientific community to bolster our science education, and NSF's style of getting scientists to set science education policy and design effective programs began over 20 years ago. Don't blame them if the massive network of our educational system was able to bury them, and the federal commitment to quality never strong enough!

Unfortunately, no one comes forth with *why* science education is now on the wane. I think many science education leaders recognize the "why" to be a pervasive emphasis on processes at the expense of content, but, having seen the political results of bucking the traditional educational establishment, they shy away from proposing the expensive and painful solution of literally rebuilding an educational system. However, eventually we will acknowledge that we must pay science teachers what they are worth; we will insist on a system that elevates technical competence and uses pedagogy as a means rather than an end; we will accept that a technically literate America will cost REAL money; and we will demand a federal role that comprises leadership without dictatorship. The sooner the better.

J. C. Kellett Jr.

Fairfax, Va.

The high cost of books

SIR: I just received a book ad from a major publisher of chemical books. It includes a new book that I should very much like to read. The 600-page book, of general interest to chemists, is described as " 'Must' reading for all involved in chemistry." It is priced at $95.95. Apparently the publisher anticipates a small volume of sale. The price tag absolutely guarantees a self-fulfilling prophecy.

A price tag of almost $100 for a medium-sized book of broad interest suggests to me one or more of four things. Either (a) more books are being published than can reasonably be expected to sell, or (b) book publishers are making monstrous profits, or (c) excessively expensive methods and materials are used in the design and printing of books, or (d) marketing strategies are badly faulted.

The first of these is almost certainly true. The second I doubt very much. The third is almost certainly true of most technical books today, but probably not true of most technical journals. The last may well be true of a broad range of literature from general interest books to *Chemical Abstracts*. Certainly very expensive publications will have a small volume of sale (and a correspondingly small readership?).

Are we moving toward a time when a large volume of technical literature will be available in only a single copy in the Library of Congress, so that we must all go to Washington to read it?

B. Spencer Meeks

Professor of Chemistry, Moorhead State University, Moorhead, Minn.

Corrections

- May 17, page 9: The bars on the sales, earnings, profit margins, production, and prices graphs are labeled incorrectly—the last bar in each graph is for first-quarter 1982.
- May 31, page 24: Lewis M. Branscomb is still vice president and chief scientist at IBM. He is not a former employee as stated.

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Surplus of iodine now, but shortage coming

Slow industrial demand and federal stockpile reductions are depressing producers' sales, but soon rebounding demand will create shortage

With the wounds inflicting the economy, a kiss and a dab of iodine won't make things better. But if it did, it also would help the iodine business, because many of the industries iodine is sold to are suffering with the slumping economy. And the outlook for iodine for the rest of the year is not promising. To top off the situation, when the iodine industry does turn around, it probably will enter a period of serious shortages.

This year, the iodine industry has been hit by a double whammy. First, the recession has soured many industries it sells to—and delayed the development of other promising markets. Indeed, iodine consumption this year is predicted to amount to only about 6.5 million lb—down from historical levels of about 8 million to 8.1 million lb per year. On its own, that would hurt U.S. suppliers, of whom there are only two—PPG Industries and Dow Chemical—and cut into imports, which long have been the mainstay of U.S. iodine supply. But another major factor has entered the business: The U.S. government late last year began selling stockpiled iodine to reduce its inventories.

"The government's sale couldn't have come at a worse time," says one iodine product manager. The sale of iodine was part of a general inventory-reduction program, but, this marketer says, the other commodities involved generally have been sold at the going market price. With iodine, on the other hand, the prices started out about 12% less than the market price of $6.53 to $6.54 per lb—itself discounted from a list price of about $7.25 per lb. The General Services Administration has indicated that it intends to sell 2.213 million lb from stockpile, so last year's sales and an expected 1 million lb this year will clear up most of that as a materials source.

However, while GSA is conducting its sales, and with the drop in demand this year, producers are trimming their capacity. U.S. capacity probably was a little shy of 2.5 million lb at the beginning of the year, with PPG accounting for 2 million lb per year at its Woodward, Okla., plant, and Dow the remainder at Midland, Mich.

And several announced projects are marking time, if not resting on the back burner. Calabrian International, a New York-based marketing firm that probably is the major importer of iodine in the U.S., had announced plans several years ago to build an iodine recovery plant, in conjunction with Ise Chemical Industries Ltd. Ise produces about half the iodine produced by Japanese interests, which in turn accounts for about half the world's supply. However, when marketers at Calabrian saw the slowdown and the GSA sales impending, "we stopped dead in our tracks" with the recovery plant, says one official there.

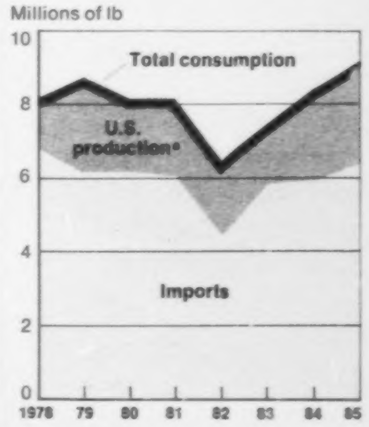
Dow had announced plans to build a new iodine extraction plant in southern California to complement its "senior-citizen" Midland operations, which date from 1927. Some Dow customers say they have been told the company has dropped the plans altogether, but Dow says that it is merely proceeding more slowly with them than it originally had anticipated.

A joint venture among Oklahoma City-based Beard Oil Co., Godoe USA (a subsidiary of Japanese iodine manufacturer United Resources Industry), and Inorgchem Developments Inc. was scheduled to come on stream this quarter, but has been delayed slightly. It will start up this fall. This venture, North American Brine Resources, initially plans three mini-units, for a combined capacity of 143,000 lb per year; it hopes to expand that capacity with more wells later on.

One problem facing North American Brine Resources may be low iodine levels in the brines, other producers believe. Most iodine is obtained as a by-product of bromine recovery, although the most recent production facilities, such as PPG's, which is a joint venture with Amoco Chemicals, are for iodine only. For bromine, a respectable concentration is in the 4000- to 5000-ppm range. For iodine, however, a "rich" brine contains a scant 300 ppm. With lower concentrations than that, producers can have difficulty running an economically efficient recovery process.

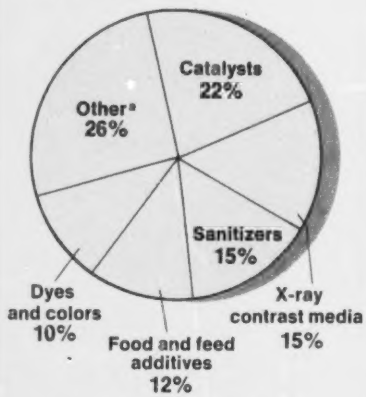
The prospects of improved busi-

Imports dominate the iodine market



[a] Includes stockpile sales from 1981 to 1983.
Sources: Bureau of Mines. C&EN estimates

Where iodine goes



Total 1982 consumption = 6.5 million lb

[a] Includes stabilizers (7%), photographic film (5%), other pharmaceutical (5%), and water treatment (4%).
Sources: Bureau of Mines, C&EN estimates

ness, however, have made the chance worth the effort. This year will be bleak, marketers agree, but next year will be much better—so much so, in fact, that the industry will be heading back into the shortage side of its traditional cycle.

This year, iodine has been carried by sales into the medical world, though not as simple tincture of iodine, which, incidentally, has fallen out of favor with medical practitioners. Major sales, rather, consist of far more sophisticated diagnostic agents such as sodium iodide scintillating crystals. These are used to pinpoint tumors, help determine the extent of damage in stroke cases, and assess brain damage in accident victims. An even larger market in diagnostics is with x-ray contrast media, basically iodinated amines of benzoic acid with as high as 47% iodine content. Injected into the bloodstream, the fluids—opaque to x-rays because of the high iodine content—reveal blood flow, outlines of various organs, and other diagnostic information. Recently developed formulations promise a more comfortable replacement for the barium sulfate used in gastrointestinal tests.

The other major use for iodine, as a catalyst for industrial processes, has suffered, however. Calabrian, for one, sees several large-scale end uses for iodine catalysts: methanol conversion to acetic acid, thermochemical power cycles using iodine, coal liquefaction catalysts, and hydrocarbon oxidative dehydrogenation. A generally depressed chemical industry, however, has been a poor customer for catalysts. And one of those major uses—coal liquefaction—is in danger of disappearing altogether as companies call off proposed projects.

Nevertheless, Calabrian president Charles A. Cogliandro see things picking up as Tennessee Eastman, for example, brings on stream its methanol-to-acetic acid plant this year. Next year, a similar plant is scheduled for Canada, with others scheduled for Taiwan and Yugoslavia—all boosting world demand for iodine, he says.

That kind of new demand, the ending of GSA sales, and a rebound in normal demand help make this year's surplus deceiving, marketers agree, with the industry heading into a period of significant shortages. By one prediction, demand will readily top 9 million lb in 1985. And even with imports from Japan and the other major importing country, Chile, there will be problems filling that demand.

Patricia Layman, New York

CHECKOFF

NEW PLANTS

■ **Aramid fiber**—Du Pont will increase capacity 20% during 1982 at Spruance plant near Richmond, Va.; material sold under Nomex tradename.

■ **Carbon dioxide**—Airco Industrial Gases will spend $3 million at Hopewell, Va., plant to raise capacity to more than 400 tons per day as part of $25 million program to expand company's carbon dioxide production.

■ **Chlorine**—Vulcan Chemicals will expand Geismar, La., plant 12%, bringing chlorine capacity to 675 tons per day and caustic soda capacity to 720 tons per day; project to be completed in fall 1983 at cost of $12.5 million.

■ **Fatty amides**—Witco Chemical will expand Memphis, Tenn., plant of its Humko Chemical division, raising capacity 50% to make both primary and secondary fatty amides used primarily as plastics additives; cost not disclosed; completion slated for first-quarter 1983.

■ **Gas processing**—Phillips Petroleum will build new unit near Dumas, Tex., to process cryogenically 60 million standard cubic feet per day of gas to remove nitrogen, crude helium, and C_2+ hydrocarbons. Work will be handled by Lotepro Corp., New York City, and will be completed in fourth quarter of 1982.

■ **Genetic products**—Genentech will build 72,000-sq-ft plant at South San Francisco, Calif., to make genetically engineered products such as human and animal growth hormones, interferons, and vaccines. Fluor subsidiary Daniel International will build plant, due for completion by end of 1982.

■ **Methyl *tert*-butyl ether**—Texas Olefins will build 25,000 metric-ton-per-year unit for making this gasoline additive on 200-acre site near Baytown, Tex. Accelerated completion date of end of 1982 is possible because company is partly using existing equipment that will use process technology licensed from Arco Technology.

■ **Polyvinyl chloride**—B. F. Goodrich will increase capacity 25% at Pedricktown, N.J., plant for making polymer as dispersion resin; cost not disclosed; completion scheduled for fourth-quarter 1983.

■ **Specialty chemicals**—Ferro Corp. will spend $6 million to expand plants at Hammond, Ind., and Bedford, Ohio, for flame-retardant additives and ultraviolet light stabilizers.

■ **Sulfonates**—Witco Chemical will add 50 million lb per year of continuous sulfonation capacity at Houston organics division plant at cost of about $8 million. When completed in first-quarter 1983, total capacity at site will be about 100 million lb.

PLANTS COMPLETED

■ **Alum**—Allied Chemical has started up what it calls first new plant built by major supplier of aluminum sulfate in decade. Unit, at Ashdown, Ark., has capacity of 30,000 tons per year.

■ **Butylated hydroxy toluene**—Sherwin-Williams' chemical division has completed 10 million lb-per-year plant at Fords, N.J.; product used as an antioxidant.

■ **Chlorine**—Georgia - Pacific has started operational pilot plant at Phoenix using Diamond Shamrock technology and Du Pont's Nafion 901 membranes.

■ **Dyes**—Crompton & Knowles has added unit at Newark, N.J., plant to make several dyes used primarily in printing ink and paper industries.

■ **Insecticides**—Shell Chemical has started unit at Mobile, Ala., plant to make its Pydrin insecticide; product is structurally related to naturally occurring pyrethrins.

■ **Isocyanate**—BASF Wyandotte now is operating new diphenylmethane diisocyanate unit at Geismar, La. Capacity is 150 million lb per year, but current operations are at 100 million lb annual rate. Technology for process was developed at BASF in West Germany.

Canadian methanol enters alternate fuel market

With large supplies available because of booming capacity, methanol is in good position to compete with compressed natural gas and propane

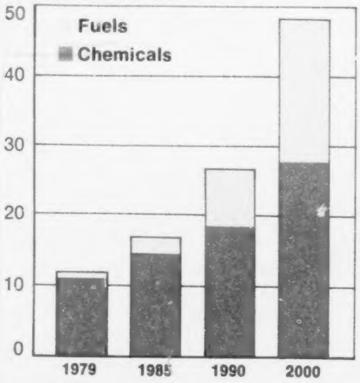
Celanese Canada, with its huge 700,000 metric-ton-per-year methanol plant at Edmonton, Alta., nearing completion, has decided to enter methanol in the Canadian alternate fuel sweepstakes.

Methanol will have to compete against several other contenders, including compressed natural gas and propane. Just how big a role, if any, methanol will play in the Canadian transportation fuel market still is unclear. But Celanese Canada is confident that, of them all, methanol is the one fuel that is capable of having the most significant impact.

At a recent meeting of the Chemical Institute of Canada, Neil Martin, vice president of Celanese Canada's chemicals and industrial products group, explained why. One big factor in methanol's favor, Martin says, is availability. Canadian methanol capacity is about to take a quantum leap. Alberta Gas Chemical already has doubled its methanol capacity at Medicine Hat, Alta., from 360,000 metric tons to 720,000 metric tons annually. And, in addition to the Celanese world-scale unit soon to be on stream in Edmonton, Ocelot Industries will be coming in with its 360,000 metric-ton-per-year unit at Kitimat, B.C. When all of these units are operating, Canada's methanol capacity will jump from 410,000 metric tons (last year) to 1.8 million metric tons (next year).

Fuels hold big market potential for methanol

Global methanol demand, millions of metric tons



Source: Celanese Canada

Conventional methanol demand in Canada won't even come close to keeping pace. Formaldehyde accounts for about 40% of methanol consumption and the formaldehyde outlook isn't particularly encouraging. The country's stagnant economy, a slumping construction industry, and even weak exports of building boards are taking their toll among formaldehyde producers.

Martin estimates that next year Canadian methanol demand will be 274,000 metric tons, only modestly higher than what it was last year. That will leave more than 1.5 million metric tons of Canadian surplus methanol available for export—or for the alternate fuel market in Canada itself.

Martin equates that amount of surplus methanol to about 5% of the Canadian gasoline pool. But he emphasizes that by 1983 there will be enough Canadian methanol available in the form of a low-percentage blend in gasoline to satisfy all of Canada's fuel requirements.

A low-percentage blend is the strategy that Celanese Canada has chosen to push. The company is working primarily with a 4.75% blend of methanol with gasoline for a variety of reasons. Not only will enough methanol be available to support the low-percentage blend approach as early as next year, but Canadians will be able to use the blend without any modification to their car engines.

Methanol in low-percentage blends, Martin says, can use Canada's existing gasoline distribution network. A 4.75% blend in gasoline with an equal amount of cosolvent already is approved in the U.S. by the Environmental Protection Agency, and Martin says that tests to confirm EPA findings now are under way in Canada. Martin points out that in the U.S. the 4.75% blend with cosolvent is covered by automobile warranties. He expects that a similar situation would develop in Canada, too.

Why methanol may succeed as gasoline octane booster

Celanese Canada thinks that a low-percentage (4.75%) blend of methanol can play a big role as a gasoline octane modifier in Canada. Here's why:

Supply: Enough to satisfy national requirements by 1983

Distribution: Can use existing gasoline distribution network

Acceptance: 4.75% blend with cosolvent is approved by U.S. EPA. Confirmatory fleet tests are under way in Canada

Auto compatibility: Does not require vehicle modification; covered by automobile warranties in U.S.

Timing: Can start in 1983

Market: All cars can use it

Economics: Methanol blends are economically viable today and will become more attractive in the future

Environmental impact: Methanol is an extremely clean-burning fuel. Supported by EPA in the U.S. and by Environment Canada

Celanese studies indicate that the economics are right today for a Canadian refiner to use methanol as an octane booster. These economics will improve in the future, he predicts.

Obviously, Celanese Canada intends to use the experience developed in the U.S. and in several western European countries as a major selling point for its low-percentage blend approach in Canada. But to confirm that existing data also apply to Canada, with its lower ambient temperatures, the company is coordinating a demonstration program to show that 4.75% methanol with cosolvent is acceptable under Canadian driving conditions. The program, which includes fleet tests in Montreal and Toronto plus laboratory and dyna-

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Canada's methanol capacity to increase

Thousands of metric tons	1981	1983
Alberta Gas Chemical		
Medicine Hat, Alta.	360	720
Celanese Canada		
Cornwall, Ont.	50	50
Edmonton, Alta.	—	700
Ocelot Industries		
Kitimat, B.C.	—	360
TOTAL	410	1830
Conventional Canadian demand	250	275
Surplus for export	160	1555

Source: Celanese Canada

mometer tests, is under way and will operate for about one year.

Celanese is confident that this program will confirm that a low-percentage methanol blend is compatible with an unmodified car. It also is confident that it can win the refinery economics battle as well.

Methanol, Martin says, will have to compete with several other octane-improving alternatives available to a refiner, such as tetraethyllead, higher-severity reforming, or toluene addition. Tetraethyllead is the refiner's least expensive source of octane, but leaded gasoline is under environmental review in Canada. If Canada's relatively high lead levels in gasoline are phased down, refiners will have to increase the pool octane of their base stock.

This, Martin notes, is an important aspect of methanol's valuation as an octane booster. The reason: Many Canadian refineries, especially in eastern Canada, already are tight on octane-producing capability. "Methanol could be a cheap, viable alternative for these refineries," he says. And low-percentage methanol blends won't need a government subsidy to make them attractive.

But methanol won't capture the Canadian alternate-fuel market uncontested. J. Judd Buchanan, president of CNG Fuel Systems Ltd., says that his company was formed a year and a half ago to wean Canada's vehicles from gasoline to compressed natural gas. And Ontario has a Drive Propane program in progress to promote propane as a transportation fuel. In both these approaches, supply certainly is no problem, and the distribution network is in place. Both, however, require modifying the car. A low-percentage methanol blend doesn't, and Celanese is hoping that this is its ace in the hole.

Earl Anderson, New York

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Facts & Figures

for the chemical industry

A year ago, the U.S. chemical industry appeared ready to shift into high gear. Output had labored upward to regain just about all the ground lost during the recession of 1980, and industry executives generally were confident that it soon would be climbing to new highs. Optimistic forecasts were widespread. The recession, though painful, also seemed to be happily brief.

Prospects were still clouded, to be sure. Demand remained weak in many key markets for chemicals, such as automobiles, home building, and appliances, as continuing high interest rates dampened consumer purchases. Export markets, too, were soft, reflecting a worldwide economic slump and the rising cost of U.S.-made products.

Nevertheless, at mid-1981 the consensus was that the year as a whole would shape up markedly better than 1980 and that 1982 would bring some further growth.

As it turned out, however, from midyear on it has been all downhill. The data spread across the following pages of Facts & Figures, C&EN's annual statistical review of the chemical industry, clearly show that 1981 proved to be little, if any, better than 1980. Moreover, as the 1982 edition of Facts & Figures goes to press, it is still by no means clear when the current business slump will bottom out.

Facts & Figures contains data gathered together from a broad assortment of sources, including government agencies, trade associations, international organizations, and the companies themselves that make up the multifaceted chemical industry. These data have been treated by the C&EN staff, in many cases, to develop analytical measures and comparisons in order to add perspective to the recent performance of the chemical industry.

Facts & Figures at a glance

Section One: Production

After a relatively strong first half, production of chemicals declined markedly during the last six months of 1981. For the year as a whole, as a result, output was little if any higher than in the previous lackluster year. Plastics were up, although only to about the level of 1979. But for basic chemicals, it was a standoff year, with inorganic chemicals particularly weak. Page 32

Section Two: Finance

Although total U.S. shipments of chemicals and allied products climbed 9% last year, the increase stems from higher prices (up 11% overall) rather than an increase in the physical volume of demand. And as output slumped during the second half of 1981, so did profits. The result was erosion of the industry's profitability for the second year in a row. Stagnant demand is putting a crimp in chemical companies' capital spending plans, as well. But it has not dimmed their enthusiasm for research, with R&D support rising sharply in the past three years. Page 39

Section Three: Performance

The 1% increase in productivity eked out by chemical companies last year is a slight improvement but well below average gains during the past decade. Page 61

Section Four: Employment

Employment in the chemical industry overall essentially was unchanged last year from the year before. But it has been declining since last summer and now is below the lowest level reached during the 1980 recession. Page 65

Section Five: Foreign Trade

World trade in chemicals declined in 1981 in dollar volume, but U.S. exports of chemicals increased, giving the U.S. a bigger share of the worldwide market. The increase in U.S. exports was a slim 2%, however, far below the gains chalked up during the previous two years. Meanwhile, imports climbed almost 10%, pushing down the chemical trade surplus for the first time since 1972. Page 67

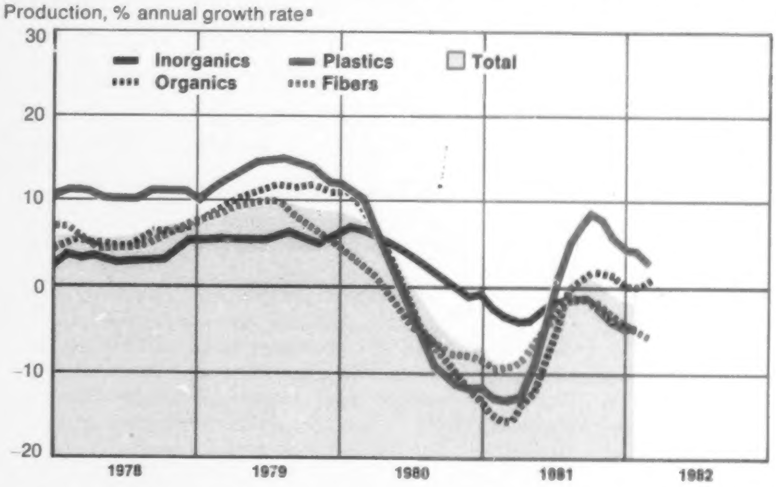
Section Six: Foreign chemical industries

Chemical industries throughout the world were in the doldrums last year. In Western Europe, output was down in the U.K. and Italy, but up slightly in West Germany, France, and elsewhere. Earnings, however, remained depressed just about everywhere. In Eastern Europe, growth rates slowed despite relatively modest targets. Japan's industry remained beset by high raw material costs. And Canadian producers, despite a favorable raw materials position, saw profits squeezed by slumping demand and weak prices. Page 69

1 Production by the U.S. Chemical Industry

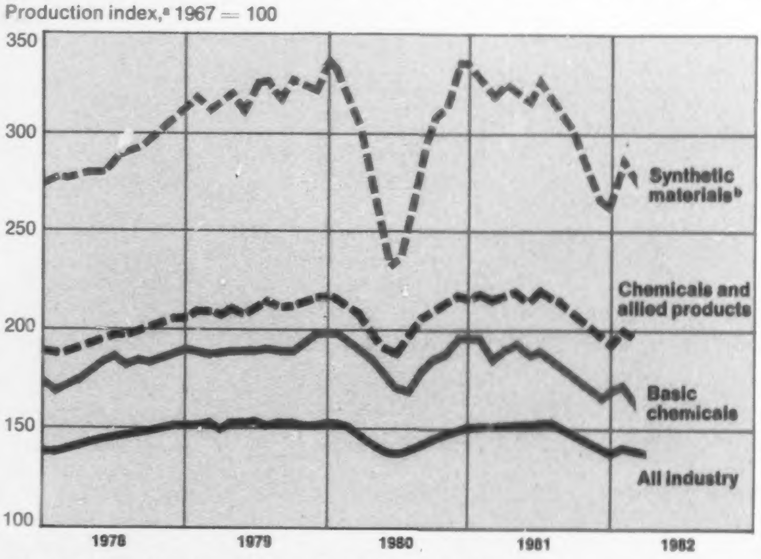
Output down for many big-volume chemicals

Recovery in chemical production petered out in late 1981



a Average running annual growth rates in production of major plastics, inorganic and organic chemicals, and all chemicals, and in shipments of man-made fibers. **Sources:** International Trade Commission, Bureau of the Census, Society of the Plastics Industry, Textile Economics Bureau

For the second time in two years, chemical output slumps



a Seasonally adjusted. b Includes plastics, synthetic rubber, and man-made fibers.
Source: Federal Reserve Board

Producers of chemicals in the U.S. were turning out about the same volume of product at the start of 1981 as they had been 12 months earlier, having recovered fully from the sharp but short recession of 1980. Production was maintained on a high plateau throughout the first half of 1981. But as the summer waned, the business climate turned markedly chillier. Output, as a consequence, has been dwindling steadily and now is off close to 20% for both basic chemicals and synthetic materials (plastics, man-made fibers, and synthetic rubber) from a year and a half ago.

Because of the relatively good first six months, production of chemicals eked out a small gain last year, compared to that of recession-wracked 1980. But it failed to match 1979's total. Whatever strength the industry showed, moreover, was focused largely on plastics and, to a lesser extent, man-made fibers. And in many major product areas, the slump during the second half dragged output for the year as a whole below the disappointing level of the year before.

The weakest performance was among inorganic chemicals, with production off 5 to 6% overall, as softening demand for fertilizer materials during the second half of the year compounded the continuing decline for alkalies and chlorine. Production of chlorine and caustic soda slid 8% on the heels of a similar decline the year before. Sulfuric acid likewise was off 8%, phosphoric acid 9%, ammonium nitrate 4%, and ammonia 3%, reflecting the worsening fertilizer market.

Plastics regained much of the ground lost the year before, with polyolefins chalking up the best results among the large-volume polymers, although the picture there, too, was turning increasingly dismal during the final months of 1981. Fibers also made a modest recovery.

Increased production of plastics and fibers put a little luster on organics, but in general for them it was a standoff year. On a product-by-product basis, output was down as often as not, and some of the declines were quite sharp.

TOP 50 CHEMICALS: Production was lower in 1981 for the second year straight

Rank 198	Rank 1980[a]		Production, Billions of lb, 1981	Production, Billions of lb, 1980	Production, Common units[b], 1981	Production, Common units[b], 1980	Average annual change 1980–81	Average annual change 1979–80	Average annual change 1976–81	Average annual change 1971–81
1	1	**Sulfuric acid**	81.35	88.54	40,674 tt	44,272 tt	−8.1%	5.4%	3.1%	3.4%
2	2	**Ammonia**	38.07	38.09	19,037 tt	19,044 tt	−0.1	5.1	2.6	2.7
3	5	**Nitrogen**	37.31	34.71	485 bcf	479 bcf	1.3	16.0	11.0	11.2
4	4	**Lime**[c]	35.99	35.36	17,969 tt	17,680 tt	1.6	−8.8	−1.2	−0.4
5	3	**Oxygen**	34.93	35.68	422 bcf	431 bcf	−2.1	0.9	1.7	2.9
6	6	**Ethylene**	28.87	28.67	28,867 mp	28,667 mp	0.7	−4.1	5.6	4.6
7	7	**Sodium hydroxide**	21.30	23.25	10,649 tt	11,625 tt	−8.4	−6.2	0.3	1.0
8	8	**Chlorine**	21.12	22.84	10,559 tt	11,421 tt	−7.5	−5.7	0.3	1.2
9	9	**Phosphoric acid**	19.83	21.88	9,914 tt	10,938 tt	−9.3	7.9	4.5	5.2
10	11	**Nitric acid**	18.08	17.47	9,040 tt	8,733 tt	3.5	2.0	3.0	1.7
11	10	**Ammonium nitrate**[d]	17.58	18.25	8,791 tt	9,127 tt	−3.7	17.0	4.1	2.8
12	12	**Sodium carbonate**[e]	16.56	16.55	8,281 tt	8,275 tt	0.1	0.3	1.8	1.5
13	14	**Urea**[f]	14.97	12.96	14,970 mp	12,960 mp	15.5	−8.7	8.9	8.1
14	13	**Propylene**	14.02	13.68	14,016 mp	13,676 mp	2.5	−3.7	7.5	7.4
15	19	**Toluene**[g]	10.32	7.37	1,424 mg	1,017 mg	40.0	−38.0	4.6	5.0
16	15	**Benzene**	9.91	11.60	1,348 mg	1,585 mg	−15.0	20.0	−1.4	2.3
17	16	**Ethylene dichloride**	9.17	11.11	9,171 mp	11,108 mp	−17.4	−5.9	3.0	2.0
18	20	**Methanol**	8.41	7.15	8,408 mp	7,153 mp	17.8	−2.9	6.1	5.5
19	18	**Carbon dioxide**[h]	7.96	7.44	3,982 tt	3,720 tt	7.0	5.3	14.1	11.5
20	17	**Ethylbenzene**	7.85	7.64	7,847 mp	7,642 mp	2.7	−10.0	5.1	4.7
21	23	**Vinyl chloride**	6.72	6.47	6,720 mp	6,466 mp	3.9	1.2	3.2	4.5
22	21	**Styrene**	6.61	6.86	6,612 mp	6,856 mp	−3.6	−8.4	1.0	3.5
23	22	**Xylene**	6.43	6.59	887 mg	909 mg	−2.5	−4.3	−2.6	3.8
24	24	**Terephthalic acid**[i]	6.35	6.05	6,350 mp	6,054 mp	4.9	−1.7	4.7	10.6
25	26	**Formaldehyde**[j]	5.86	5.56	5,855 mp	5,555 mp	5.4	−6.9	0.8	2.6
26	27	**Ethylene oxide**	5.11	5.22	5,109 mp	5,220 mp	−2.1	−7.9	2.1	3.6
27	25	**Hydrochloric acid**	4.89	5.79	2,443 tt	2,895 tt	−15.6	−2.2	−0.6	1.5
28	29	**Ammonium sulfate**	4.22	4.27	2,111 tt	2,136 tt	−1.2	8.4	0.5	1.5
29	28	**Ethylene glycol**	4.06	4.39	4,055 mp	4,386 mp	−7.5	−7.3	3.8	2.8
30	30	***p*-Xylene**	3.70	4.24	3,696 mp	4,238 mp	−12.8	−8.9	2.9	8.3
31	31	**Cumene**	3.31	3.46	3,306 mp	3,459 mp	−4.4	−11.7	4.2	4.4
32	33	**Butadiene**[k]	3.05	2.80	3,046 mp	2,799 mp	8.8	−21.9	−2.9	−0.7
33	36	**Carbon black**	2.73	2.55	2,730 mp	2,546 mp	7.2	−24.0	−2.0	−1.0
34	32	**Acetic acid**	2.71	2.98	2,706 mp	2,977 mp	−9.1	−8.8	2.2	3.3
35	35	**Phenol**[l]	2.55	2.57	2,551 mp	2,568 mp	−0.7	−13.9	3.1	3.9
36	34	**Aluminum sulfate**	2.41	2.57	1,206 tt	1,286 tt	−6.2	4.4	0.3	0.7
37	37	**Sodium sulfate**[m]	2.33	2.28	1,164 tt	1,139 tt	2.2	−2.9	−1.1	−1.5
38	38	**Acetone**	2.17	2.08	2,167 mp	2,076 mp	4.4	−21.7	2.3	3.5
39	42	**Acrylonitrile**	2.01	1.83	2,006 mp	1,830 mp	9.6	−9.3	5.8	7.4
40	40	**Vinyl acetate**	1.93	1.92	1,934 mp	1,922 mp	0.6	−3.0	5.5	7.6
41	44	**Calcium chloride**[n]	1.83	1.62	917 tt	811 tt	13.1	−17.3	0.5	−2.8
42	43	**Propylene oxide**	1.81	1.77	1,810 mp	1,767 mp	2.4	−21.4	0.8	4.3
43	39	**Cyclohexane**	1.75	1.96	1,749 mp	1,964 mp	−10.9	−19.0	−4.3	0.1
44	41	**Isopropyl alcohol**	1.64	1.84	1,644 mp	1,836 mp	−10.5	−3.4	−0.9	−0.4
45	46	**Titanium dioxide**	1.50	1.57	750 tt	787 tt	−4.7	6.2	1.0	1.0
46	47	**Sodium silicate**	1.48	1.57	738 tt	785 tt	−6.0	1.0	−0.3	1.5
47	45	**Sodium tripolyphosphate**	1.37	1.58	687 tt	789 tt	−12.9	4.4	−1.1	−4.0
48	48	**Acetic anhydride**	1.25	1.47	1,248 mp	1,468 mp	−15.0	−2.5	−3.7	−1.9
49	50	**Adipic acid**	1.21	1.20	1,210 mp	1,200 mp	0.8	−33.3	−4.4	−0.8
50	49	**Ethanol**[l]	1.16	1.45	1,157 mp	1,451 mp	−20.3	3.1	−0.4	−3.4
		TOTAL ORGANICS IN TOP 50	**174.91**	**172.89**			**1.2%**	**−6.9%**	**3.8%**	**4.5%**
		TOTAL INORGANICS IN TOP 50	**372.84**	**383.86**			**−2.9%**	**2.5%**	**2.8%**	**2.8%**
		GRAND TOTAL OF TOP 50	**547.75**	**556.75**			**−1.6%**	**−0.6%**	**1.6%**	**3.4%**

a Revised. **b** tt = thousands of tons, bcf = billions of cubic feet, mp = millions of pounds, mg = millions of gallons. **c** Except refractory dolomite. **d** Original solution. **e** Synthetic and natural. **f** Primary solution. **g** All grades. **h** All forms. **i** Includes both acid and ester without double counting. **j** 37% by weight. **k** Rubber grade. **l** Synthetic only. **m** High and low purity. **n** Solid and liquid.
Sources: Bureau of the Census, Bureau of Mines, International Trade Commission, C&EN estimates

PRODUCTION: Generally up last year, but often not to levels of 1979

Industrial production indexes, 1967 = 100	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971	Annual change 1980–81	Annual change 1971–81
Total index	151.0	147.0	152.5	146.1	138.2	130.5	117.8	129.3	129.8	119.7	109.6	3%	3%
Manufacturing, total	150.4	146.7	153.6	146.8	138.4	130.3	116.3	129.4	129.8	118.9	108.2	3	3
Nondurable manufacturing	164.8	161.2	164.0	156.9	150.5	141.8	126.4	134.6	133.8	126.5	116.6	2	4
Chemicals and products	215.6	207.1	211.8	197.4	185.7	170.9	147.2	159.4	154.5	143.6	125.9	4	6
Chemicals and synthetic materials	228.6	222.2	234.2	216.7	201.1	185.1	154.1	176.7	171.9	156.4	135.8	3	5
Basic chemicals	186.8	187.4	192.0	181.9	171.8	161.8	135.9	153.3	147.7	137.7	123.7	0	4
Alkalies and chlorine	114.7	121.4	132.3	119.7	119.2	119.0	106.5	125.6	123.8	120.2	114.4	−6	0
Gases, coal tar, inorganic pigments	181.5	184.3	197.7	186.0	174.3	164.4	133.3	165.0	157.8	146.5	125.6	−2	4
Basic organic chemicals	236.7	231.6	233.3	221.2	204.7	189.8	155.3	177.9	170.0	155.3	139.7	2	5
Inorganic chemicals, nec	125.5	132.4	134.9	129.3	128.5	124.3	112.9	112.6	110.8	107.8	99.2	−5	2
Acids and fertilizer materials	137.2	145.9	142.0	133.6	124.2	117.6	108.4	116.6	113.1	111.5	105.3	−6	3
Synthetic materials	313.7	293.3	320.1	287.6	260.8	232.5	191.0	224.4	221.1	194.7	160.4	7	7
Plastics materials	429.3	386.5	420.1	366.5	320.3	280.1	213.1	258.5	243.3	217.4	166.2	11	10
Synthetic rubber	103.3	103.2	130.5	127.5	124.5	118.7	101.2	129.7	135.6	126.9	117.2	0	−1
Man-made fibers	254.4	250.3	270.8	250.9	236.8	214.3	191.2	214.4	220.1	189.1	164.9	2	4
Chemical products	203.0	192.4	190.2	179.0	170.9	157.2	140.7	142.8	137.7	131.3	116.4	6	6
Drugs and medicines	267.1	245.7	238.2	220.6	213.9	191.5	174.1	179.6	170.1	155.5	135.1	9	7
Soap and toiletries	177.0	170.8	171.6	163.8	155.0	143.0	127.7	128.1	129.0	130.3	114.1	4	4
Paints	127.4	130.5	137.8	132.6	125.8	122.8	114.2	119.2	114.7	118.0	111.1	−2	1
Agricultural chemicals	241.4	230.5	221.6	211.8	201.1	185.4	163.9	144.6	127.0	108.9	103.5	5	9
Petroleum products	129.7	132.9	143.9	145.2	142.6	133.5	124.1	124.7	128.5	122.1	116.7	−2	1
Rubber and plastics products	274.0	255.7	272.2	253.6	232.3	199.7	166.7	195.2	184.1	172.4	147.6	7	6

nec = not elsewhere classified. **Source:** Federal Reserve Board

MINERALS: Output of fertilizer raw materials declined in 1981

Thousands of tons	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971	Annual change 1980–81	Annual change 1971–81
Bromine, sold or used[a]	189[b]	189	249	223	217	230	204	216	209	193	178	0%	1%
Calcium chloride, production[c,d]	917	811	981	1,031	968	897	828	1,101	858	914[e]	952[e]	13	0
Iodine, consumption[f,g]	4.3[b]	4.4	4.4	4.0	4.3	3.6	3.1	3.8	3.5	3.4	3.3	−2	3
Imports[g]	3.0	3.1	3.1	3.4	3.5	3.2	2.7	4.0	3.1	3.1	3.6	−3	−2
Lime, sold or used[h]	18,701[b]	19,037	20,983	20,484	19,987	20,257	19,159	21,645	21,132	20,332	19,635	−2	0
Lithium, consumption[f,i]	3.2[b]	3.0	3.2	3.4	4.1	2.8	2.9	3.8	3.2	2.7	2.6	7	2
Phosphate rock													
Marketable production	59,110	59,982	56,891	55,156	52,091	49,231	48,806	45,676	42,128	40,823	38,878	−1	4
Exports	11,459	15,737	15,827	14,187	14,584	10,398	12,270	13,895	13,873	14,272	12,584	−27	−1
Potash (K_2O equivalent)[j]													
Production	2,377	2,468	2,453	2,484	2,457	2,400	2,501	2,552	2,604	2,659	2,587	−4	−1
Imports[k]	5,287	5,481	5,693	5,189	5,076	4,594	3,797	4,325	3,587	2,961	2,766	−4	7
Apparent consumption	6,850	6,999	7,626	6,840	6,605	6,149	5,113	6,086	5,563	4,816	4,815	−2	4
Salt, total sold or used[l]	38,914	40,396	45,820	42,896	43,439	44,218	41,057	46,565	43,939	45,051	44,106	−4	−1
Evaporated	6,208	6,358	6,248	5,872	5,704	5,634	5,372	5,951	5,913	5,879	5,956	−3	0
Rock	11,871	11,806	14,891	14,688	14,958	15,668	14,283	14,835	12,347	14,434	13,700	1	−1
Salt in brine[m]	20,835	22,231	24,681	22,336	22,777	22,917	21,401	25,779	25,680	24,737	24,449	−6	−2
Sodium carbonate, production[d]	8,281	8,275	8,253	8,290	8,040	7,560	7,130	7,566	7,535	7,523	7,163	0	1
Sulfur, production[n]	13,388	13,080	13,339	12,318	11,824	11,992	12,610	12,789	12,231	11,444	10,730	2	2
Apparent consumption[o]	14,093	15,056	15,145	13,889	12,850	12,060	11,875	12,115	11,463	11,036	10,274	−6	3
Frasch, production	6,997	7,044	7,007	6,226	6,520	7,016	8,077	8,849	8,518	8,165	7,868	−1	−1
Recovered elemental, production	4,695	4,490	4,486	4,478	3,995	3,514	3,326	2,948	2,706	2,184	1,787	5	10
Other, production	1,695	1,547	1,845	1,615	1,310	1,462	1,208	992	1,008	1,096	975	10	6

a Elemental bromine sold as such or used in preparation of bromine compounds by primary producers. b Preliminary figure. c 75% $CaCl_2$ equivalent. d Natural and synthetic. e C&EN estimate. f Estimated apparent consumption. g Crude elemental iodine. h Includes Puerto Rican production. i Lithium content basis. j Includes muriate and sulfate of potash, potassium magnesium sulfate, and parent salts; excludes other chemical compounds containing potassium. k Includes nitrate of potash. l Total obtained by all recovery methods that was sold or used by domestic producers (figures differ slightly from U.S. production figures); figures include Puerto Rican production. m Sold or used as such. n Sulfur content basis. o Calculated from shipments plus imports minus exports (sulfur content basis). **Source:** Bureau of Mines

ORGANIC CHEMICALS: Output fell in 1981 more often than it rose

Millions of lb unless otherwise noted	Production											Annual change	
	1981[a]	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971	1980–81	1971–81
Acetic acid, synthetic	2,706	2,977	3,265	2,776	2,570	2,463	2,197	2,584	2,429	2,235	1,956	−9%	3%
Acetone	2,167	2,076	2,653	2,519	2,219	1,869	1,640	1,980	1,989	1,818	1,538	4	3
Acrylonitrile	2,006	1,830	2,018	1,752	1,646	1,518	1,215	1,412	1,354	1,115	979	10	7
Aniline	635	659	690	606	584	544	407	551	458	410	366	−4	6
Benzene, mg[b,c]	1,348	1,585	1,673	1,488	1,457	1,425	1,024	1,488	1,453	1,252	1,076	−15	2
Bisphenol A	510	530	576	471	455	449	293	370	320	255	187	−4	11
1,3-Butadiene[d]	3,046	2,799	3,583	3,515	3,259	3,507	2,597	3,682	3,644	3,527	3,340	9	−1
Butanol	823	790	766	756	660	625	490	558	519	590	466	4	6
Caprolactam	926	905[e]	945	919	867	780	713	668	656	640	575	2	5
Carbon disulfide	na	377	448	476	505	508	479	782	777	768	753	na	na
Carbon tetrachloride	717	710	714	737	809	857	906	1,163	1,047	997	1,009	1	−3
Cumene	3,306	3,459	3,917	3,380	2,644	2,716	2,003	2,906	2,665	2,293	2,144	−4	4
Cyclohexane	1,749	1,964	2,425	2,332	2,265	2,187	1,734	2,352	2,123	2,298	1,748	−11	0
Diisodecyl phthalate	134	122	175	171	161	143	106	147	171	153	136	10	0
Dodecylbenzene[f]	513	563[e]	627	526	526	529	495	533	498	524	550	−9	−1
Ethanol, synthetic	1,157	1,451	1,408	1,267	1,339	1,496	1,429	1,618	1,962	1,851	1,630	−20	−3
Ethanolamines[g]	408	376	420	362	308	286	258	307	293	284	259	9	5
Ethyl chloride	314	396	582	540	612	669	575	662	660	576	620	−21	−7
Ethylbenzene	7,847	7,642	8,448	8,385	8,312	5,770	4,822	6,048	5,688	5,676	4,984	3	5
Ethylene	28,867	28,667	29,904	25,955	25,172	22,475	20,499	23,891	22,329	20,852	18,450	1	5
Ethylene dichloride	9,171	11,108	11,794	11,001	10,997	8,042	7,977	9,165[h]	9,293[h]	7,809	7,558	−17	2
Ethylene glycol	4,055	4,386	4,729	3,904	3,675	3,335	3,809	3,341	3,278	3,761	3,070	−8	3
Ethylene oxide	5,109	5,220	5,665	5,012	4,364	4,184	4,467	4,200[i]	4,167	3,962	3,598	−2	3
2-Ethylhexanol	389	367	318	420	493	450	387	395	402	526	287	6	4
Formaldehyde, 37%[j]	5,855	5,555	5,971	6,381	6,046	5,449	4,558	5,764	6,424	5,652	4,522	5	3
Isopropyl alcohol	1,644	1,836	1,900	1,730	1,888	1,936	1,521	1,939	1,835	1,790	1,674	−10	0
Maleic anhydride	304	304	323	341	294	264	216	290	282	274	229	0	3
Methanol, synthetic	8,408	7,153	7,367	6,443	6,453	6,242	5,176	6,878	7,064	6,472	4,950	18	5
Methyl chloride	362	362	463	454	476	378	366	493[h]	544[h]	454	437	0	−2
Methyl ethyl ketone	626	587	656	661	512	428	425	506	541	509	484	7	3
Methyl chloroform	604	692	716	644	635	631	459	592	548	441	375	−13	5
Methylene chloride	559	564	633	570	478	538	497	609	520	471	401	−1	3
Perchloroethylene	698	765	773	725	614	669	679	734	706	734	705	−9	0
Phenol, synthetic[k]	2,551	2,568	2,981	2,682	2,338	2,121	1,746	2,298	2,241	2,052	1,744	−1	4
Phthalic anhydride	811	818	1,013	978	926	902	702	977	1,023	933	794	−1	0
Propylene[c]	14,016	13,676[l]	14,198[l]	13,014[l]	13,328[l]	10,030[l]	8,709[l]	10,475[m]	9,884[m]	8,472[m]	6,891[m]	2	7
Propylene glycol	480	488	610	547	489	517	391	510	502	563	421	−2	1
Propylene oxide	na	1,767	2,249	2,047	1,866	1,823	1,524	1,756	1,753	1,520	1,194	na	na
Styrene, monomer	6,612	6,856	7,484	7,186	6,867	6,301	4,673	5,956	5,975	5,941	4,682	−4	4
Terephthalic acid, dimethyl ester[n]	6,350	6,054	6,159	5,954	5,410	5,051	4,614	4,262	2,564[o]	4,405[p]	3,574	5	6
Toluene, mg[b,c]	na	1,017	1,010	1,054	1,018	999	705	922	958	916	876	na	na
Vinyl acetate	1,934	1,922	1,982	1,692	1,586	1,481	1,290	1,403	1,503	1,211	931	1	8
Vinyl chloride	6,720	6,466	6,389	6,941	5,986	5,677	4,196	5,621	5,351	5,089	4,336	4	4
***o*-Xylene**	947	995	1,082	1,013	985	854	703	1,056	1,068	832	785	−5	2
***p*-Xylene**	3,696	4,238	4,650	3,516	3,172	2,911	2,484	2,707	2,326	2,208	1,662	−13	8

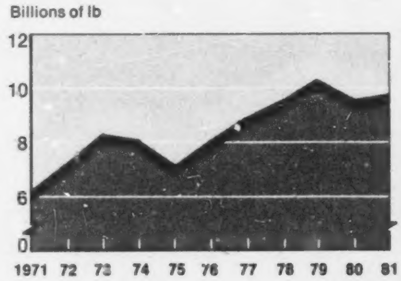
a Preliminary. b Tar distillers not included; includes material for use in blending motor fuels. c All grades. d Rubber grade. e Preliminary figure; final figure not available. f Includes straight-chain dodecylbenzene, tridecylbenzene, and other straight-chain alkylbenzenes. g Mono-, di-, and triethanolamines. h Production figure may be too low, because some methyl chloride and ethylene dichloride was produced but not separated or measured accurately by some producers. i Approximate. j By weight. k Does not include data for coke ovens and gas retort ovens. l Includes refinery propylene. m Includes data for propane-propylene mixture. n Includes both acid and dimethyl ester (DMT), without double counting. o Includes only dimethyl ester. p Figure may be too high because of possible double counting of some acid and ester. na = not available. **Source:** International Trade Commission.

INORGANICS: Output in 1981 dropped almost across the board

Thousands of tons unless otherwise noted	Production											Annual change	
	1981[a]	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971	1980-81	1971-81
Aluminum sulfate[b]	1,206	1,286	1,315	1,309	1,255	1,202	1,146	1,257	1,233	1,193	1,127	−6%	1%
Ammonia,[c,d] 100%	19,038	19,654	18,634	17,119	17,765	16,716	16,419	15,733	15,208	15,169	14,538	−3	3
Ammonium nitrate,[e] 100%	8,791	9,128	8,293	7,210	7,177	7,186	7,088	7,542	7,235	6,863	6,635	−4	3
Ammonium sulfate,[d,f] 100%	2,111	2,136	2,363	2,449	2,264	2,010	2,106	2,120	1,987	1,858	1,821	−1	1
Carbon dioxide[g]	3,982	3,720	3,780	3,228	2,817	2,064	1,850	1,804	1,566	1,610	1,344	7	11
Chlorine gas[h]	10,559	11,421	12,291	11,052	10,573	10,378	9,167	10,753	10,402	9,854	9,352	−8	1
Hydrochloric acid,[i] 100%	2,443	2,895	3,090	2,793	2,668	2,542	2,009	2,470	2,534	2,360	2,099	−16	2
Hydrogen,[j,k] bcf, 100%	102	106	106	90	85	82	74	82	65	59	56	−4	6
Nitric acid,[l] 100%	9,039	9,230	8,916	7,934	7,987	7,791	7,527	8,120	8,398	7,981	7,638	−2	2
Nitrogen gas,[j,m] bcf, 100%	485	479	427	379	328	289	252	243	227	194	168	1	11
Oxygen,[j,m] bcf, 100%	422	431	456	430	392	388	353	390	389	352	319	−2	3
Phosphoric acid, 100% P_2O_5	9,914	10,939	10,318	9,637	8,745	7,949	7,677	7,213	6,927	6,712	5,970	−9	5
Phosphorus[n]	424	432	460	441	430	437	450	524	526	541	545	−2	−2
Sodium hydroxide, 100%	10,649	11,625	12,759	11,309	11,000	10,516	9,635	11,189	10,734	10,216	9,667	−8	1
Sodium phosphate[o]	687	789	840	824	717	724	770	903	967	1,033	1,040	−13	−4
Sodium silicate[p]	737	786	813	829	760	747	724	770	723	661	636	−6	1
Sodium sulfate,[q] 100%	1,163	1,139	1,121	1,174	1,199	1,232	1,227	1,348	1,437	1,327	1,356	2	−2
Sulfuric acid,[r] 100%	40,675	44,273	43,204	41,314	38,337	34,878	32,360	33,936	31,949	31,183	29,035	−8	3
Titanium dioxide,[s] 100%	750	727	742	701	687	713	603	787	785	693	678	3	1
Urea, 100%	7,421	7,830	7,000	6,273	5,072	4,498	3,799	3,789	3,543	3,467	3,125	−5	9

a Preliminary. **b** Commercial, 17% Al_2O_3; includes municipalities except in 1981. **c** Synthetic anhydrous. **d** Excludes by-product ammonia liquor and ammonium sulfate. **e** Original solution. **f** Synthetic and noncoke by-product. **g** Solid, liquid, and gas; excludes quantities produced and consumed in plants making soda ash or urea, and quantities produced and transferred to other plants for further processing. **h** Includes quantities liquefied for use, storage, or shipment. **i** Includes anhydrous hydrochloric acid production. **j** High- and low-purity gas. **k** Liquid and gas; excludes amounts vented and used as fuel, and amounts produced in petroleum refineries for captive use. **l** Includes unspecified amounts of nitric acid produced but not withdrawn from the system. **m** Excludes amounts produced and consumed in making synthetic ammonia or ammonia derivatives. **n** Elemental, white (yellow), and red. **o** Tripolyphosphate (100% $Na_5P_3O_{10}$). **p** Soluble silicate glass (water glass), solid and liquid (anhydrous); excludes amounts produced and consumed in making meta-, ortho-, and sesquisilicates. **q** Anhydrous, high and low purity, and Glauber's salt. **r** Gross (new and fortified). **s** Composite and pure. **Note:** bcf = billions of cubic feet. **Sources:** Department of Commerce, International Trade Commission

MAN-MADE FIBERS: U.S. output recovered only modestly from 1980's depressed levels

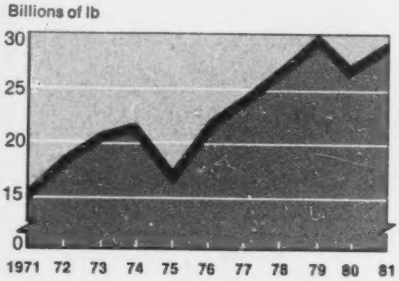


Man-made fibers production

Millions of lb	Production											Annual change	
	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971	1980-81	1971-81
CELLULOSIC FIBERS													
Acetate[a]	261	316	324	308	290	298	313	382	462	429	476	−17%	−6%
Rayon	509	490	606	597	598	543	436	817	895	965	915	4	−6
NONCELLULOSIC FIBERS													
Acrylic[b]	691	779	761	726	709	621	525	631	742	626	545	−11	2
Nylon[c]	2332	2358	2,720	2550	2326	2075	1857	2124	2175	1974	1595	−1	4
Olefins[d]	785	748	759	692	635	577	497	531	492	416	322	5	9
Polyester	4176	3989	4,178	3800	3642	3340	2995	2926	2888	2328	1142[e]	5	na
Textile glass	1041	867	1,014	923	787	676	546	683	688	572	468	20	8
Other	22[f]	19[f]	18[f]	16[f]	16[f]	14[f]	12[f]	12[f]	13[f]	11[f]	688[g]	16	na
TOTAL	**9817**	**9566**	**10,381**	**9611**	**9002**	**8144**	**7181**	**8105**	**8354**	**7322**	**6152**	**3%**	**5%**

a Includes diacetate and triacetate; excludes production for cigarette filtration. **b** Includes modacrylic. **c** Includes aramid. **d** Includes olefin yarn and monofilaments, and olefin and vinyon staple and tow. **e** Does not include yarn and monofilaments. **f** Includes only yarn and monofilaments; yarn is chiefly saran and spandex. **g** Includes only yarn and monofilaments; yarn includes polyester, anidex, saran, spandex, vinyon, and TFE fluorocarbon. **na** = not available. **Source:** Textile Economics Bureau

Plastics production



PLASTICS: Production recovered last year, but remained below 1979 peak

Millions of lb[a]	Production											Annual change	
	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971	1980–81	1971–81
THERMOSETTING RESINS													
Epoxy[b]	336	315	361	299	261	244	198	249	223	184	165	7%	7%
Polyester[c]	997	947	1,147	1,209	1,061	[illegible]	834	911	1,051	933	730	5	3
Urea	1,165	1,165	1,367	1,122	963	[illegible]	690	835	867	739	636	0	6
Melamine	179	167	200	202	200	[illegible]	115	164	170	171	168	7	1
Phenolic[d]	2,333[e]	1,499	1,781	1,617	1,458	1,340	1,051	1,335	1,387	1,453	1,194	na	na
TOTAL	**5,010**	**4,094**	**4,857**	**4,448**	**3,943**	**3,631**	**2,888**	**3,494**	**3,698**	**3,481**	**2,893**	**na**	**na**
THERMOPLASTIC RESINS													
Polyethylene													
Low density[f]	7,693	7,291	7,793	7,111	6,471	5,813	4,743	5,973	5,803	5,274	4,458	6	6
High density[g]	4,695	4,405	5,010	4,201	3,652	3,125	2,468	2,837	2,637	2,325	1,924	7	9
Polypropylene	3,955	3,648	3,841	3,074	2,747	2,632	1,902	2,249	2,162	1,726	1,288	8	12
Acrylonitrile-butadiene-styrene	916	920	1,191	1,134	1,069	988	642	857	877	810	686[h]	0	3[i]
Styrene-acrylonitrile	107	111	124	120	115	113	109	109	121	99	77[h]	−4	3[i]
Polystyrene	3,621	3,521	4,005	3,823	3,446	3,195	2,662	3,364	3,322	3,139	2,553	3	4
Styrene-butadiene copolymers and other styrene resins	829	785	916	878	813	756	585	679	703	624	433	6	7
Polyamide, nylon type	312	274	327	275	254	247	135	204	205	157	110[h]	14	11[i]
Polyvinyl alcohol	139	141	148	127	119	123	118	142	96	62	58[h]	−1	9[i]
Polyvinyl chloride and copolymers	5,707	5,470	6,119	5,723	5,253	4,716	3,648	4,850	4,562	4,259	3,471	4	5
Other vinyl resins[j]	208	196	220	197	197	225	187	209	199	194	167[h]	6	2[i]
TOTAL	**28,182**	**26,762**	**29,694**	**26,663**	**24,136**	**21,933**	**17,199**	**21,473**	**20,687**	**18,669**	**15,225**	**5%**	**6%**[i]

a Dry-weight basis, unless otherwise specified. **b** Unmodified. **c** Unsaturated. **d** Includes other tar acid resins. **e** Gross weight basis. **f** 0.940 density and below. **g** Density above 0.940. **h** Data from International Trade Commission. **i** Annual change calculated for 1971–81 is approximate because figures from Society of the Plastics Industry for 1981 and International Trade Commission for 1971 are not completely comparable. **j** Includes polyvinyl butyral, polyvinyl formal, and polyvinylidene chloride. **na** = not available. **Sources:** Society of the Plastics Industry, International Trade Commission

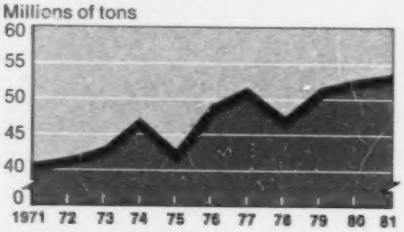
SYNTHETIC RUBBER: Output remained depressed in 1981 for the second year in a row

Thousands of metric tons	Production											Annual change	
	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971	1980–81	1971–81
Styrene-butadiene rubber[a]	1032	1074	1378	1395	1395	1333	1179	1466	1537	1500	1439	−4%	−3%
Polybutadiene	342	311	397	378	361	352	290	310	337	299	258	10	3
Nitrile	66	63	75	73	70	73	55	88	84	75	66	5	0
Ethylene-propylene	178	144	175	174	158	130	84	126	120	91	61	24	11
Polychloroprene	143	151	183	161	165	165	144	163	na	na	na	−5	na
Butyl			194	154	149	125	80	164	160	131	108	−4	−1[b]
Polyisoprene					62	74	61	93	119	134	118		
Other[c]	261[d]	272[d]	132[d]	138[d]	56	51	47	88	270[e]	226[e]	226[e]		
TOTAL	**2022**	**2015**	**2534**	**2475**	**2418**	**2304**	**1941**	**2498**	**2627**	**2456**	**2278**	0%	−1%

a Excludes high-styrene latex (more than 45% styrene). **b** Annual change for 1971–81 calculated by comparing polychloroprene plus other (including butyl and polyisoprene) in 1981 with butyl, polyisoprene, and other (including polychloroprene) in 1971. **c** Excludes polyurethane rubber. **d** Includes butyl rubber in 1980–81 and polyisoprene in 1978–81. **e** Includes polychloroprene (neoprene). **na** = not available. **Sources:** Rubber Manufacturers Association, Department of Commerce

1 Production by the U.S. Chemical Industry

Fertilizer consumption



Note: Years ending June 30.
Source: Department of Agriculture

FERTILIZERS: Higher exports help bolster U.S. production . . .

Thousands of tons	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971	Annual change 1980–81	Annual change 1971–81
NITROGEN (N)													
Domestic production	13,036	12,323	11,106	10,466	10,789	10,572	9343	10,094	9447	8971	8924	6%	4%
Imports	2,455	2,566	2,165	1,866	1,842	1,218	1198	1,068	882	843	929	−4	10
Exports	3,088	2,641	2,468	1,778	1,251	1,239	1115	1,269	1508	1032	1077	17	11
Domestic supply	12,403	12,248	10,803	10,554	11,380	10,551	9426	9,893	8821	8782	8776	1	4
PHOSPHATE (P_2O_5)													
Domestic production	10,471	10,012	9,432	8,245	7,793	7,199	7230	6,869	6387	6150	5736	5	6
Imports	250	239	236	229	245	221	274	315	312	326	283	5	−1
Exports	4,381	3,925	3,848	3,290	2,501	2,175	1860	1,581	1422	1102	898	12	17
Domestic supply	6,340	6,326	5,820	5,184	5,537	5,245	5644	5,603	5277	5374	5121	0	2
POTASH (K_2O)													
Domestic production	2,262	2,474	2,519	2,176	2,584	2,313	2287	2,604	2690	2432	2490	−9	−1
Imports	5,487	5,403	5,085	4,948	4,955	3,910	3847	4,114	3192	3088	2510	2	8
Exports	876	1,048	999	1,003	994	911	848	947	922	657	620	−16	4
Domestic supply	6,873	6,829	6,605	6,121	6,545	5,312	5286	5,771	4960	4863	4380	1	5

. . . as domestic consumption shows little growth

Thousands of tons	Consumption 1981	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971	Annual change 1980–81	Annual change 1971–81
TYPE													
Mixed fertilizer	23,340	23,270	23,742	22,110	24,099	22,958	20,647	24,067	22,547	21,511	21,513	0%	1%
Primary nutrient material	27,853	27,221	25,600	23,511	24,999	23,935	19,959	20,897	19,275	18,385	18,389	2	4
Secondary and micronutrients	2,136	2,296	2,139	1,877	2,525	2,296	1,878	2,130	1,466	1,310	1,216	−7	6
TOTAL	**53,329**	**52,787**	**51,481**	**47,497**	**51,624**	**49,189**	**42,484**	**47,094**	**43,288**	**41,206**	**41,118**	1%	3%
PRIMARY NUTRIENT CONTENT													
Nitrogen (N)	11,784	11,407	10,715	9,965	10,647	10,412	8,601	9,157	8,295	8,022	8,134	3	4
Phosphate (P_2O_5)	5,424	5,432	5,606	5,096	5,630	5,228	4,507	5,099	5,085	4,864	4,803	0	1
Potash (K_2O)	6,243	6,245	6,244	5,526	5,834	5,210	4,453	5,083	4,649	4,327	4,231	0	4
TOTAL	**23,451**	**23,083**	**22,565**	**20,587**	**22,111**	**20,849**	**17,561**	**19,338**	**18,029**	**17,213**	**17,168**	2%	3%

Note: Years ending June 30. **Source:** Department of Agriculture

NITROGEN OUTPUT: Ammonia is top product

Thousands of tons (N)	1981	1980	1979	1971	Change 1980–81
Ammonia[a]	5,455	5,270	4,603	4132	4%
Ammonium nitrate[b,c]	1,225	1,096	1,137	1176	12
Urea	1,704	1,572	1,201	562	8
Ammonium sulfate[c]	555	521	509	598	7
All other	4,097	3,864	3,656	2456	6
TOTAL	**13,036**	**12,323**	**11,106**	**8924**	**6%**

a Includes aqueous solutions. b Includes ammonium nitrate-limestone mixtures. c Adjusted for estimated quantity going into nonfertilizer uses. **Note:** Years ending June 30. **Source:** Department of Agriculture

PHOSPHATE OUTPUT: Up 5% last year

Thousands of tons (P_2O_5)	1981	1980	1979	1971	Change 1980–81
Ammonium phosphate[a]	6,015	5,519	5082	2277	9%
Concentrated superphosphate	1,713	1,737	1901	1462	−1
Normal and enriched superphosphate	357	384	320	626	−7
All other	2,386	2,372	2129	1371	1
TOTAL	**10,471**	**10,012**	**9432**	**5736**	**5%**

a Liquid and solid, excluding that combined with potash salts in process of manufacture.

Profits remain under pressure despite higher prices, sales

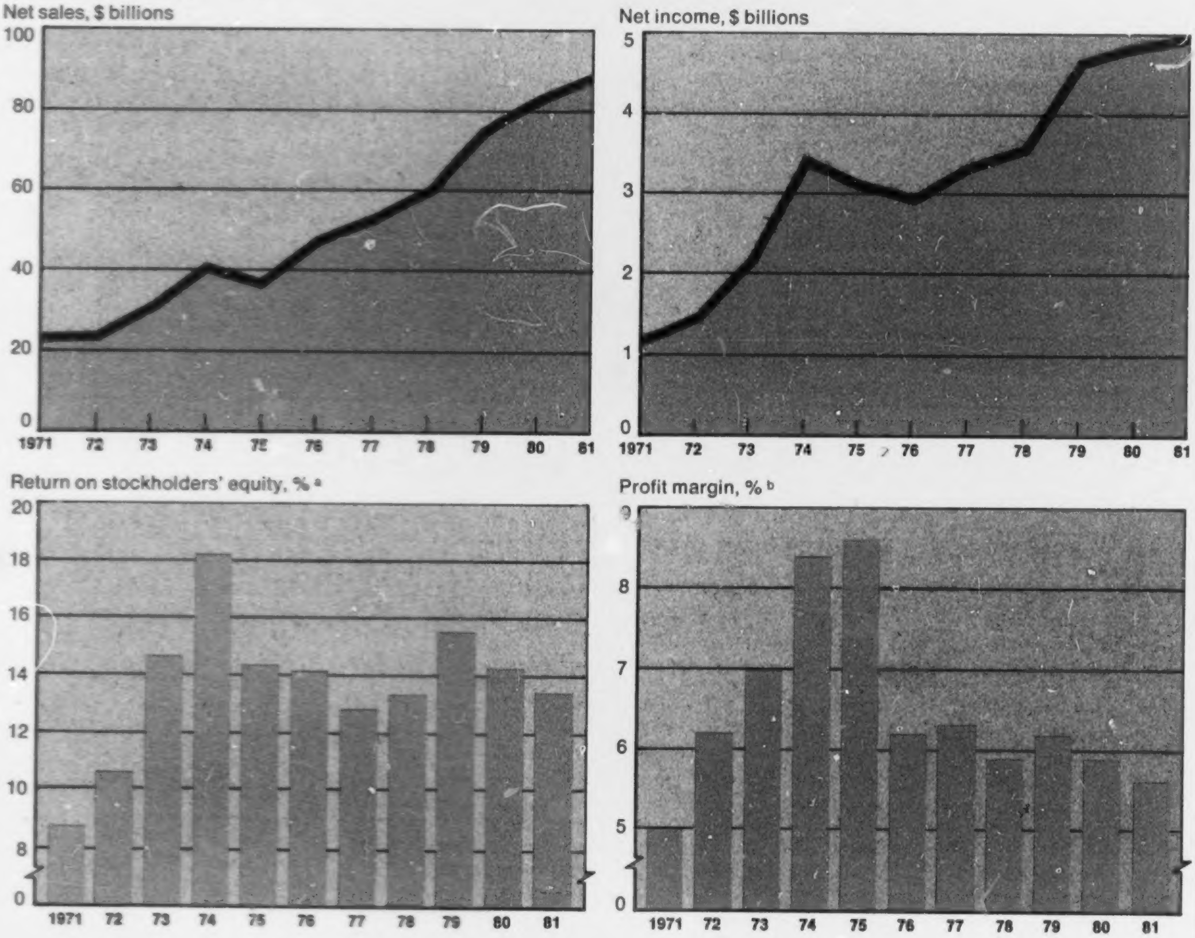
U.S. chemical producers managed to lift their sales a relatively modest 7% last year. That's only about half the annual rate of growth over the past decade.

Last year's gain, moreover, stems almost solely from higher selling prices. If producers of industrial chemicals had not been able to hike the price tags on their products an average of 11% during the year, sales growth would have been nonexistent. Even so, price increases for chemicals during 1981 were considerably smaller than the 23% rise registered during 1980 or the 17% increase of 1979.

Higher prices also helped chemical companies hold profits relatively steady for the second year—during a time when earnings were severely depressed in several other U.S. industries. Chemical companies enjoyed fairly high earnings during the first half of 1981, only to watch them sag sharply during the last few months of the year, as demand dwindled and output was cut back steadily.

Higher prices, too, were insufficient to offset higher operating costs and sliding operating rates. As a result, profitability was eroded further in 1981. Margins on sales, in fact, fell away to the lowest level since the start of the 1970s.

Chemical firms' earnings have grown little since 1979, despite higher sales, as profitability slumps



a After-tax earnings as a percentage of stockholders' equity. b After-tax earnings as a percentage of net sales. **Note:** Data based on annual figures of 40 largest industrial chemical companies.

TOP 100 CHEMICAL PRODUCERS: Their chemical sales total more than $130 billion . . .

Rank 1981	Rank 1980[a]	Company	Chemical sales 1981 ($ millions)	Change from 1980	Chemical sales as % of total sales	Industry classification	Chemical operating profits[b]	Change from 1980	Chemical operating profits as % of total operating profits	Operating profit margin[c]	Identifiable chemical assets	Chemical assets % of total assets	Operating return on chemical assets[d]
1	1	**Du Pont**	$12,189	14.1%	53.4%	Basic chemicals	$1155	15.8%	40.5%	9.5%	$8268	37.9%	14.0%
2	2	**Dow Chemical**	9,387[e]	7.7	79.3	Basic chemicals	612	−37.0	66.8	6.5	8636	69.1	7.1
3	3	**Exxon**	8,449	2.7	7.5	Petroleum	271[f]	−32.6	5.0	3.2	4937	7.8	5.5
4	4	**Monsanto**	6,311[e]	5.5	90.8	Basic chemicals	672	273.3	90.8	10.6	5224	86.1	12.9
5	5	**Union Carbide**	5,575	6.9	54.8	Basic chemicals	580	−12.3	49.3	10.4	6008	57.6	9.7
6	6	**Celanese**	3,691	15.0	98.4	Basic chemicals	198	21.5	90.0	5.4	2450	81.9	8.1
7	7	**Shell Oil**	3,578	12.8	16.5	Petroleum	15	−91.4	0.4	0.4	3462	18.8	0.4
8	8	**Standard Oil (Ind.)**	3,088	7.6	9.7	Petroleum	210	−24.2	5.5	6.8	3792	12.3	7.6
9	13	**Atlantic Richfield**	2,739	21.7	9.7	Petroleum	16	−88.0	0.5	0.6	2728	13.8	0.6
10	9	**W. R. Grace**	2,666	−1.1	40.9	Specialty chemicals	379	−1.0	47.2	14.2	1721	35.9	22.0
11	10	**Allied**	2,653	8.3	41.4	Basic chemicals	189	2.2	17.6	7.1	1810	33.9	10.4
12	14	**Phillips Petroleum**	2,470	9.8	15.5	Petroleum	140	−13.6	5.1	5.7	1544	16.1	9.1
13	11	**Gulf Oil**	2,412	−1.1	8.0	Petroleum	−59	def	def	def	1701	8.3	def
14	12	**Occidental Petroleum**	2,406	−0.8	15.7	Petroleum	108	−15.0	4.8	4.5	1922	25.9	5.6
15	16	**Eastman Kodak**	2,349	13.5	22.7	Photo equipment	289	−8.8	14.0	12.3	1680	17.8	17.2
16	17	**Mobil**	2,325	23.0	3.4	Petroleum	122	−30.3	2.0	5.2	1797	5.2	6.8
17	15	**Hercules**	2,273	8.5	83.6	Basic chemicals	170	28.8	94.4	7.5	1534	91.5	11.1
18	18	**American Cyanamid**	1,945[e]	4.5	53.3	Basic chemicals	198	10.0	56.1	10.2	1488	60.1	13.3
19	20	**Rohm & Haas**	1,761	9.5	93.4	Basic chemicals	187	−3.6	106.9	10.6	1109	97.9	16.9
20	19	**Stauffer Chemical**	1,726	1.8	100.0	Basic chemicals	261	34.5	100.0	15.1	1638	80.5	15.9
21	21	**Tenneco**	1,589	−3.1	10.3	Petroleum	36	−58.1	1.9	2.3	1244	7.4	2.9
22	25	**Texaco**	1,525	13.3	2.6	Petroleum	143	11.7	2.3	9.4	1062	3.9	13.5
23	23	**Ethyl Corp.**	1,515[e]	−0.1	86.2	Basic chemicals	154	0.7	85.6	10.2	958	75.9	16.1
24	24	**U.S. Steel**	1,427	−0.7	10.2	Steel	11	−84.5	1.6	0.8	727	5.5	1.5
25	22	**Borden**	1,424[e]	−8.0	32.3	Dairy products	141	−22.5	45.8	9.9	1144	49.2	12.3
26	33	**American Hoechst**	1,391	24.1	86.5	Basic chemicals	na	na	na	na	na	na	na
27	28	**FMC**	1,383	13.5	41.1	Machinery	195	72.6	62.7	14.1	1114	40.7	17.5
28	26	**Air Products**[g]	1,362	7.9	86.8	Basic chemicals	204	4.6	87.2	15.0	1499	79.9	13.6
29	32	**International Minerals**[h]	1,347	17.7	48.6	Agriculture chemicals	254	−4.9	78.4	18.9	1384	70.1	18.4
30	34	**Ashland Oil**	1,330	20.8	13.7	Petroleum	41	−30.5	23.0	3.1	463	11.3	8.9
31	29	**Ciba-Geigy**	1,297	9.7	69.7	Specialty chemicals	na	na	na	na	na	na	na
32	37	**Mobay Chemical**	1,270	18.8	100.0	Basic chemicals	na	na	100.0	na	1303	100.0	na
33	36	**Union Oil of Calif.**	1,248	14.8	11.0	Petroleum	111[i]	6.7	14.0	8.9	701	9.2	15.8
34	31	**Standard Oil of Calif.**	1,219	5.5	2.7	Petroleum	31[i]	−8.8	1.3	2.5	917	3.9	3.4
35	35	**Diamond Shamrock**	1,152	4.9	34.1	Basic chemicals	150	32.7	40.7	13.0	1075	35.6	14.0
36	41	**Olin**	1,077	16.6	53.8	Basic chemicals	80	27.0	44.2	7.4	947	60.9	8.4
37	27	**CF Industries**	1,054[e]	−14.5	100.0	Agriculture chemicals	81	−66.1	100.0	7.7	1133	100.0	7.1
38	38	**B. F. Goodrich**	1,050	2.7	33.0	Rubber products	48	−20.0	43.6	4.6	1261	46.7	3.8
39	39	**PPG Industries**	1,012	5.0	30.2	Glass products	120	−16.7	31.9	11.9	1004	34.0	15.8
40	30	**Williams Cos.**	985[e]	−15.9	49.8	Agriculture chemicals	35	−80.1	22.9	3.6	1018	41.6	3.4
41	40	**BASF Wyandotte**	967	5.3	100.0	Basic chemicals	24	84.6	100.0	2.5	791	100.0	3.0
42	43	**Reichhold Chemicals**	950	7.3	100.0	Basic chemicals	35	29.6	100.0	3.7	401	98.0	8.7
43	42	**Lubrizol**	899	−2.5	100.0	Specialty chemicals	149	−22.0	100.0	16.6	582	86.5	25.6
44	44	**National Distillers**	823	−1.0	40.0	Alcoholic beverages	134	6.3	71.3	16.3	606	36.1	22.1
45	45	**Farmland Industries**[j]	816	11.2	14.8	Agricultural supplies	67	−40.7	31.2	8.2	454	24.2	14.8
46	47	**Sun Co.**	746	12.9	5.0	Petroleum	na	na	na	na	na	na	na
47	47	**Georgia-Pacific**	738[e]	11.6	13.6	Wood products	149	−2.6	37.6	20.2	947	18.7	15.7
48	46	**Dow Corning**	722	5.9	100.0	Specialty chemicals	76	2.7	100.0	10.5	787	100.0	9.7
49	54	**Akzona**	694	20.9	58.4	Basic chemicals	25	def	46.3	3.6	432	51.7	5.8
50	52	**Koppers**	678[e]	17.5	33.6	Diversified chemicals	29	−38.3	20.4	4.3	377	28.4	7.7

a Revised. **b** Operating profit defined as sales less administrative expense and cost of selling. **c** Operating profit as a percentage of chemical sales. **d** Operating profit as a percentage of identifiable chemical assests. **e** Chemical sales include significant amounts of nonchemical products. **f** Chemical net profit. **g** Fiscal year ended Sept. 30, 1981. **h** Fiscal year ended June

. . . and they are split about equally between the chemical industry and other industries

Rank 1981	Rank 1980[a]	Company	Chemical sales 1981 ($ millions)	Change from 1980	Chemical sales as % of total sales	Industry classification	Chemical operating profits[b]	Change from 1980	Chemical operating profits as % of total operating profits	Operating profit margin[c]	Identifiable chemical assets	Chemical assets % of total assets	Operating return on chemical assets[d]
51	50	**Nalco Chemical**	$667	8.1%	100.0%	Specialty chemicals	$122	6.1%	100.0%	18.3%	$227	75.1%	34.9%
52	49	**Borg-Warner**	664	5.2	24.0	Auto equipment	61	3.4	29.6	9.2	316	22.5	19.3
53	53	**Merck**	664[e]	15.5	22.7	Drugs	73	25.9	12.6	11.0	547	16.5	13.3
54	51	**Pennwalt**	641	7.7	60.7	Basic chemicals	73	43.1	60.3	11.4	436	68.3	16.7
55	64	**El Paso**	576	22.6	14.7	Natural gas	13	−61.8	3.0	2.3	425	11.5	3.1
56	61	**Uniroyal**	573	17.4	25.4	Tires	79	−23.3	50.6	13.8	415	28.5	19.0
57	55	**NL Industries**	565	2.4	22.9	Petroleum services	77	40.0	15.3	13.6	358	15.6	21.5
58	65	**Badische**	563	24.3	100.0	Basic chemicals	25	13.6	100.0	4.4	410	100.0	6.1
59	62	**Esmark[k]**	561[e]	15.4	17.9	Food	47	nc	24.4	8.4	354	20.3	13.3
60	56	**Freeport-McMoRan**	554	5.1	66.3	Agricultural chemicals	148	9.6	62.2	26.7	313	21.1	47.3
61	57	**Aluminum Co. of America**	553[e]	5.7	11.0	Nonferrous metals	na	na	na	na	na	na	na
62	59	**Kerr-McGee**	543	8.4	14.2	Petroleum	35	−5.4	7.2	6.4	685	20.1	5.1
63	60	**Kaiser Aluminum**	533	8.6	16.5	Nonferrous metals	74	39.6	26.7	13.9	481	12.5	15.4
64	65	**Witco Chemical**	510	12.6	39.5	Specialty chemicals	48	37.1	43.2	9.4	239	33.0	20.1
65	69	**Airco**	500	19.0	41.7	Basic chemicals	na	na	na	na	na	na	na
66	68	**Cabot[g]**	492	11.6	30.3	Specialty metals	66	nc	26.7	13.4	286	22.7	23.1
66	58	**Eli Lilly**	492	−5.0	17.7	Drugs	na	na	na	na	na	na	na
68	63	**Standard Oil (Ohio)**	481	1.1	3.5	Petroleum	34	−39.3	0.8	7.1	525	3.3	6.5
69	67	**International Flavors**	451	0.7	100.0	Specialty chemicals	102	−3.8	100.0	22.6	375	87.0	27.2
70	73	**National Starch**	450	25.3	67.4	Specialty chemicals	na	na	na	na	na	na	na
71	71	**Beatrice Foods**	446	14.7	4.9	Food	63	26.0	8.3	14.1	na	na	na
72	70	**Pfizer**	421	1.2	13.0	Drugs	−4	def	def	def	446	12.2	def
73	75	**Mississippi Chemical[h]**	395	14.8	100.0	Farm cooperative	61	24.5	100.0	15.4	303	71.8	20.1
74	83	**Polysar**	395	45.8	100.0	Basic chemicals	12	100.0	100.0	3.0	180	100.0	6.7
75	72	**Internorth**	368	2.2	10.1	Natural gas	49	−29.0	11.6	13.3	407	10.7	12.0
76	77	**American Petrofina**	335	5.7	13.4	Petroleum	8	−57.9	6.4	2.4	248	21.6	3.2
77	78	**Liquid Air**	327	4.8	80.1	Basic chemicals	46	4.5	90.2	14.1	378	78.1	12.2
78	79	**GAF**	325	5.5	48.3	Diversified chemicals	57	9.6	def	17.5	201	35.9	28.4
79	76	**Upjohn**	324	−0.6	17.1	Drugs	4	−85.7	1.5	1.2	194	10.0	2.1
80	84	**Terra Chemicals**	317[e]	19.6	100.0	Agricultural chemicals	na	na	na	na	na	na	na
80	81	**Thiokol**	317	11.2	44.0	Aerospace	31	−3.1	50.0	9.8	291	62.2	10.7
82	92	**First Mississippi[h]**	308	39.4	86.0	Agricultural chemicals	44	25.7	73.3	14.3	163	51.1	27.0
83	86	**Rhône-Poulenc**	300	17.6	100.0	Specialty chemicals	na	na	na	na	na	na	na
84	88	**Vulcan Materials**	299	19.1	38.2	Nonmetallic minerals	71	42.0	52.6	23.7	236	35.0	30.1
85	87	**H. B. Fuller[l]**	280	11.1	85.1	Specialty chemicals	na	na	na	na	na	na	na
86	85	**Martin Marietta**	277	7.4	13.6	Aerospace	48	−3.1	23.1	11.8	212	22.9	12.6
86	—	**Tyler**	277	na	35.9	Diversified chemicals	26	na	32.9	9.4	163	36.1	16.0
88	82	**Emhart**	270	−3.9	15.5	Machinery	27	12.5	16.4	14.0	111	10.4	24.3
89	94	**Big Three Industries**	265	28.6	32.2	Petroleum services	79	27.4	39.1	29.8	505	49.8	15.6
90	89	**SCM[h]**	263[e]	6.5	13.6	Paint	31	−3.1	23.1	11.8	247	22.9	12.6
91	90	**Petrolite[k]**	261	12.0	87.9	Specialty chemicals	41	5.1	89.1	15.7	158	79.8	25.9
92	74	**Soltex**	250	−28.6	100.0	Basic chemicals	na	na	na	na	na	na	na
93	92	**Houston Natural Gas[m]**	248	21.4	1.6	Natural gas	14	−26.3	0.6	6.9	368	16.7	7.3
94	90	**Cities Service**	240	3.0	2.8	Petroleum	5	−68.8	0.8	2.1	340	5.6	1.5
95	96	**Engelhard**	240[e]	21.8	10.9	Specialty metals	47	30.6	44.8	19.6	203	28.8	23.2
96	80	**Beker Industries**	235	−20.3	100.0	Agricultural chemicals	na	na	na	na	na	na	na
97	95	**Loctite[h]**	214	7.4	100.0	Specialty chemicals	24	−33.3	100.0	11.2	195	107.7	12.3
98	50	**Stepan Chemical**	205	29.7	100.0	Specialty chemicals	13	116.7	100.0	6.3	176	100.0	7.4
99	48	**Getty Oil**	204	21.4	1.6	Petroleum	14	−26.3	0.6	6.9	na	na	na
100	49	**Agway**	200	21.2	9.7	Farm cooperative	na	na	na	na	na	na	na

30, 1981. **i** Net income. **j** Fiscal year ended Aug. 31, 1981. **k** Fiscal year ended Oct. 31, 1981. **l** Fiscal year ended Nov. 30, 1981. **m** Fiscal year ended July, 1981. **na** = not available. **nc** = no change. **def** = deficit.

2 Finances of the U.S. Chemical Industry

SHIPMENTS: Chemical industry sales grew at a below-average rate last year

$ Billions	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971	Annual change 1980–81	Annual change 1971–81
All manufacturing industries	$1997.8	$1845.9	$1727.3	$1523.4	$1358.4	$1185.6	$1039.1	$1017.5	$875.2	$756.3	$671.1	8%	12%
Chemicals and allied products	182.3	167.1	153.8	129.8	118.2	104.1	89.7	83.7	65.0	57.4	50.9	9	14
Industrial chemicals[a]	64.0	60.0	55.1	44.8	41.5	35.6	29.4	26.6	19.0	16.6	14.9	7	16
Drugs, soap, and toiletries	45.9	44.9	40.6	34.7	30.6	27.8	24.3	22.2	19.3	17.8	15.9	2	11
Petroleum and coal products	194.7	176.6	134.3	103.9	97.5	82.3	69.5	58.9	34.9	28.7	26.9	10	22
Rubber and plastic products, nec	46.6	48.1	48.9	43.2	39.6	31.8	27.2	27.9	24.4	20.9	17.8	−3	10
Paper and allied products	77.7	71.7	66.0	57.0	52.1	48.2	41.7	41.8	32.8	28.3	25.5	8	12

a Excluding pigments. **nec** = not elsewhere classified. **Source:** Department of Commerce

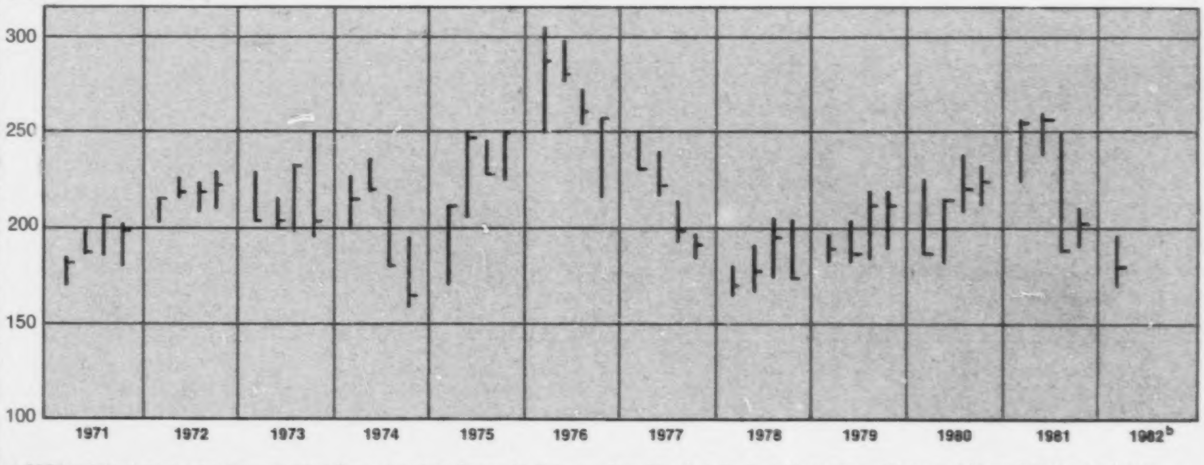
PRICES: Increases in 1981 were smaller than in 1980

Producer price indexes,[a] 1967 = 100	Annual average 1981	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971	Annual change 1980–81	Annual change 1971–81
All commodities	293.4	268.8	235.6	209.3	194.2	183.0	174.9	160.1	134.7	119.1	114.0	9%	10%
Industrial commodities	304.1	274.8	236.5	209.4	195.1	182.4	171.5	153.8	125.9	117.9	114.1	11	10
Chemicals and allied products	287.8	260.3	222.3	198.8	192.8	187.2	181.3	146.8	110.0	104.2	104.1	11	11
Industrial chemicals	363.8	324.0	264.0	225.6	223.9	219.3	206.9	151.7	103.4	101.2	102.0	12	14
Prepared paint	249.9	235.3	204.4	192.3	182.4	174.4	166.9	145.7	122.2	118.0	115.6	6	8
Paint materials	300.2	273.9	241.2	212.7	205.9	189.8	177.2	152.3	113.2	104.1	101.5	10	11
Drugs and pharmaceuticals	193.4	174.5	159.4	148.1	140.5	134.0	126.6	112.7	104.3	103.0	102.4	11	7
Fats and oils, inedible	295.6	298.0	376.7	315.8	279.0	249.9	255.2	338.2	228.3	115.8	133.6	−1	8
Agricultural chemicals and chemical products	284.8	257.1	214.4	198.4	187.8	188.4	203.6	137.7	96.6	91.7	92.1	11	12
Plastic resins and materials	289.2	279.2	235.9	199.8	195.7	194.0	180.9	143.8	92.1	88.7	88.7	4	13
Other chemicals and allied products	254.4	224.5	191.8	181.8	175.7	170.7	168.6	147.5	118.1	113.5	112.0	13	9
Rubber and plastic products	232.8	217.4	194.3	174.8	167.6	159.2	150.2	136.2	112.4	109.3	109.1	7	8

a Formerly called "wholesale price indexes." **Source:** Department of Labor

Chemical stocks have drifted down in the past year, now at level of 10 years ago

Stock price index, 1954 = 100[a]



a C&EN weighted stock price index of Allied Corp., American Cyanamid, Celanese, Dow Chemical, Du Pont, Monsanto, and Union Carbide; weighted according to number of shares outstanding for each company. b First quarter.

INDUSTRY BALANCE SHEET: Debt and capital investment rise markedly

Industrial chemicals and synthetics

Assets	1981	1980	Change
	($ billions)		
Current assets			
Cash and time deposits in U.S.	$ 0.99	$ 0.67	48
Marketable securities	1.04	0.99	5
Receivables	13.22	13.18	0
Inventories	12.79	10.83	18
Other current assets	1.96	1.92	2
Total	**30.01**	**27.58**	**9**
Fixed assets:			
Plant, property, and equipment	74.04	69.46	7
Less: accumulated depreciation and depletion	32.52	32.94	−1
Net fixed assets	**40.52**	**36.52**	**11**
Other assets, including investments and intangibles	**19.28**	**14.79**	**30**
TOTAL ASSETS	**$89.81**	**$78.89**	**14%**

Source: Federal Trade Commission

Liabilities and stockholders' equity	1981	1980	Change
	($ billions)		
Current liabilities:			
Accounts payable	$ 6.88	$ 6.86	0%
Short-term loans	1.62	2.53	−36
Accrued income taxes	0.76	1.10	−31
Current portion of long-term debt	0.63	0.62	2
Other current liabilities	6.73	5.10	32
Total	**16.62**	**16.21**	**3**
Long-term debt	**23.15**	**16.76**	**38**
Deferred taxes, minority interest, and other noncurrent liabilities	**6.25**	**6.15**	**2**
TOTAL LIABILITIES	**$46.03**	**$39.12**	**18%**
Stockholders' equity:			
Capital stock and other capital	16.43	11.52	43
Retained earnings	27.35	28.25	−3
TOTAL STOCKHOLDERS' EQUITY	**$43.78**	**$39.77**	**10%**
TOTAL LIABILITIES AND STOCKHOLDERS' EQUITY	**$89.81**	**$78.89**	**14%**

DEBT RATIOS: Up appreciably for chemical companies

$ Billions	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971
INDUSTRIAL CHEMICALS AND SYNTHETICS											
Long-term debt	$23.2	$16.8	$14.8	$13.6	$12.3	$11.8	$10.2	$7.8	$7.2	$7.6	$7.6
Stockholders' equity	$43.8	$39.8	$32.3	$29.3	$26.3	$25.0	$22.8	$20.5	$18.7	$18.5	$17.5
Debt ratio[a]	34.6%	29.6%	31.4%	31.8%	31.9%	32.0%	30.8%	27.6%	27.8%	29.2%	30.3%
CHEMICALS AND ALLIED PRODUCTS											
Long-term debt	$36.0	$28.3	$24.9	$23.5	$21.1	$19.4	$16.8	$12.8	$10.7	$11.5	$10.7
Stockholders' equity	$86.8	$79.5	$67.4	$60.8	$54.9	$50.8	$45.7	$40.9	$36.7	$36.1	$32.8
Debt ratio[a]	29.3%	26.3%	27.0%	27.9%	27.8%	27.6%	26.9%	23.8%	22.6%	24.2%	24.6%
ALL MANUFACTURING											
Long-term debt	$265.1	$236.2	$204.8	$182.0	$167.3	$153.6	$145.2	$130.1	$112.9	$118.3	$111.5
Stockholders' equity	$756.4	$699.7	$624.0	$560.8	$511.7	$475.3	$435.5	$408.4	$368.0	$353.1	$327.1
Debt ratio[a]	26.0%	25.2%	24.7%	24.5%	24.6%	24.4%	25.0%	24.2%	23.5%	25.1%	25.4%

[a] Long-term debt as a percentage of long-term debt plus stockholders' equity. **Note:** Because of changes in accounting rules and industry classifications, numbers over the entire range of years are not strictly comparable. **Source:** Federal Trade Commission

CASH FLOW: Increased outside financing reflects corporate acquisitions last year

$ Millions, % of total	1981		1980		1979		1978		1977	
SOURCES OF FUNDS										
Net income	$ 4,358	18.2%	$ 3,981	33.2%	$ 3,801	36.3%	$3085	33.6%	$2754	30.6%
Depreciation and depletion	4,267	17.9	3,818	31.8	3,602	34.4	3197	34.8	2833	31.5
Deferred taxes	1,012	4.2	679	5.7	427	4.1	353	3.8	357	4.0
Other internal sources	1,833	7.7	815	6.8	1,093	10.5	930	10.1	1214	13.5
Long-term debt	7,493	31.4	2,079	17.3	1,210	11.6	1545	16.8	1609	17.9
Stock	4,931	20.6	630	5.2	322	3.1	84	0.9	230	2.5
TOTAL	**$23,894**	**100.0%**	**$12,002**	**100.0%**	**$10,454**	**100.0%**	**$9194**	**100.0%**	**$8997**	**100.0%**
APPLICATION OF FUNDS										
Dividends	$ 1,845	7.7%	$ 1,603	13.4%	$ 1,474	14.1%	$1317	14.3%	$1184	13.1%
Capital expenditures	8,344	34.9	7,027	58.5	5,633	53.9	5080	55.3	5488	61.0
Additions to working capital	3,759	15.7	1,057	8.8	1,075	10.3	863	9.4	520	5.8
Reduction of long-term debt	1,493	6.3	1,119	9.3	1,042	10.0	879	9.5	747	8.3
Other applications	8,453	35.4	1,196	10.0	1,230	11.7	1054	11.5	1058	11.8
TOTAL	**$23,894**	**100.0%**	**$12,002**	**100.0%**	**$10,454**	**100.0%**	**$9194**	**100.0%**	**$8997**	**100.0%**

Note: Data are totals for 15 major chemical companies: Allied, American Cyanamid, Celanese, Diamond Shamrock, Dow Chemical, Du Pont, Ethyl, Hercules, Monsanto, Olin, Pennwalt, Rohm & Haas, Stauffer Chemical, Union Carbide, and Williams Cos. **Source:** Company annual reports

FINANCIAL ANALYSIS: Profitability fell for both large and smaller firms last year

	Profit margin[a]	Return on investment[b]	Debt as % of debt plus equity	% total sales abroad[c]	% total assets abroad[d]	Sales per employee[e]	Dividends as % of net income	CAPITAL SPENDING[f] as % of sales	CAPITAL SPENDING[f] as % of net plant	R&D spending as % of sales	Sales as % of assets	Net plant as % of gross plant
SALES OVER $1 BILLION												
Air Products[g]	8.0%	4.7%	29.4%	21.1%	24.3%	$ 97	18.1%	20.6%	24.8%	2.0%	83.6%	61.4%
Akzona	1.0	0.9	43.4	na	na	77	84.5	5.0	16.2	2.7	142.0	42.0
Allied	5.4	5.0	31.1	24.4	23.9	110	33.3	9.5	21.2	2.4	119.9	58.1
American Cyanamid	5.4	4.8	25.4	35.0	27.1	87	40.7	5.0	13.6	4.5	119.1	52.5
Celanese	3.8	3.1	39.8	22.5	20.4	105	44.4	11.0	27.3	2.8	125.4	43.3
Dow Chemical	4.8	3.6	44.8	47.9	44.8	186	60.6	9.9	19.0	3.4	95.0	56.2
Ethyl	5.2	5.5	19.3	24.6	15.5	121	35.0	8.0	21.3	2.1	139.2	57.8
FMC	5.2	5.3	23.4	34.9	15.9	87	31.6	8.1	22.7	3.1	122.9	59.4
B. F. Goodrich	2.9	2.7	37.1	19.0	12.4	95	39.5	17.8	42.4	1.7	117.8	61.3
W. R. Grace	5.5	7.2	40.0	24.2	17.1	73	32.4	10.1	26.0	0.8	129.9	65.6
Hercules	5.0	4.8	30.2	21.4	24.5	119	39.3	6.2	18.4	2.3	136.1	45.0
International Minerals[h]	7.7	6.1	33.3	24.4	10.6	187	43.6	17.0	27.0	na	100.5	65.7
Monsanto	6.4	5.1	25.0	29.9	25.6	121	32.6	9.6	21.0	3.2	114.5	51.2
National Distillers	6.7	7.7	19.8	na	na	na	58.5	2.2	9.1	na	119.1	53.1
Olin	4.6	3.9	27.4	5.1	10.3	148	29.7	9.3	22.0	1.9	123.7	49.4
Pennwalt	3.5	3.7	30.4	18.5	20.7	99	63.5	5.0	17.0	2.5	136.3	53.1
PPG Industries	6.3	5.3	21.2	19.3	15.8	92	36.8	11.2	21.6	3.5	113.5	59.4
Rohm & Haas	4.9	4.7	24.9	34.0	28.1	140	35.6	9.7	33.9	4.1	139.7	43.3
Stauffer Chemical	8.7	5.8	28.9	12.7	11.9	141	37.9	13.8	20.4	3.0	134.9	63.2
Union Carbide	6.4	4.7	28.5	31.4	28.7	92	34.5	11.7	20.5	2.0	97.6	57.7
Williams Cos.	5.0	3.5	35.9	na	na	282	36.1	11.8	15.6	na	80.8	70.8
Witco Chemical	3.0	4.3	33.6	13.9	14.4	156	40.9	6.4	29.5	na	178.1	56.9
MEDIAN 1981	**5.2%**	**4.8%**	**29.8%**	**24.2%**	**20.4%**	**$105**	**37.4%**	**9.7%**	**21.3%**	**2.6%**	**119.1%**	**57.3%**
MEDIAN 1980	**5.3%**	**5.0%**	**35.6%**	**27.7%**	**24.3%**	**$106**	**35.9%**	**9.7%**	**23.5%**	**2.2%**	**120.6%**	**54.2%**
SALES FROM $112 MILLION TO $1 BILLION												
Chemed	10.0	15.1	0	16.9	11.0	na	90.8	2.2	7.4	0.9	108.6	64.5
Crompton & Knowles	3.5	5.7	22.2	20.5	23.0	97	40.7	2.8	20.5	1.8	169.6	57.6
Essex Chemical	4.7	6.6	48.7	na	na	182	25.6	7.9	32.5	1.6	161.0	61.0
First Mississippi[h]	8.3	7.8	27.7	na	na	338	16.8	16.3	49.7	na	112.2	51.8
Freeport-McMoRan	19.1	8.8	33.9	na	na	161	24.5	61.9	45.1	na	56.4	71.3
H. B. Fuller[i]	4.1	7.9	23.4	30.9	46.3	100	15.4	2.1	14.8	1.8	208.0	61.1
GAF	def	def	59.0	9.6	6.1	104	0	4.1	14.1	1.2	120.1	62.7
Great Lakes Chemical	11.7	8.5	16.4	15.0	na	na	18.3	14.9	23.1	3.1	90.1	69.6
Philip A. Hunt	3.4	3.7	20.9	27.7	17.0	108	60.5	8.1	25.1	5.2	127.0	63.0
International Flavors	14.7	13.1	0	64.9	55.6	126	53.1	3.7	13.2	6.6	104.7	58.5
Liquid Air	7.4	5.2	27.7	43.8	43.8	na	56.2	14.4	21.7	1.0	88.4	62.3
Loctite[h]	4.9	5.7	0.1	44.6	52.5	83	52.9	6.2	30.8	2.7	118.0	70.9
Lubrizol	10.2	11.5	5.0	56.2	44.7	212	46.8	8.4	26.5	3.7	133.6	61.9
Nalco Chemical	12.2	14.5	3.6	20.7	24.6	141	49.3	8.9	33.6	4.6	143.0	53.1
Petrolite[j]	9.4	11.0	8.0	20.2	22.0	na	32.4	5.1	23.1	2.5	150.3	50.6
Reichhold Chemicals	1.8	3.3	29.7	14.8	18.6	170	36.8	1.7	9.2	0.7	232.5	59.5
Stepan Chemical	3.2	3.4	37.9	na	na	227	29.2	5.9	17.8	3.2	116.1	60.8
Thiokol	5.1	6.8	1.9	16.4	10.7	81	32.5	5.3	22.0	1.7	154.1	58.6
MEDIAN 1981	**6.3%**	**6.7%**	**21.6%**	**20.6%**	**23.0%**	**$134**	**34.7%**	**6.1%**	**22.6%**	**2.2%**	**123.6%**	**61.1%**
MEDIAN 1980	**7.9%**	**7.2%**	**22.7%**	**21.5%**	**22.2%**	**$142**	**33.5%**	**6.2%**	**22.7%**	**2.5%**	**129.5%**	**60.4%**

a Net income as percentage of sales. **b** Net income as percentage of current assets plus gross plant. **c** Consolidated sales only. **d** Foreign identifiable assets as percentage of total assets. **e** Thousands of dollars. **f** Actual spending on construction of new facilities and purchase of new equipment and land in consolidated businesses. **g** For fiscal year ended Sept. 30, 1981. **h** For fiscal year ended June 30, 1981. **i** For fiscal year ended Nov. 30, 1981. **j** For fiscal year ended Oct. 31, 1981. **na** = not available. **def** = deficit. **Note:** Net income is from continuing operations excluding extraordinary and nonrecurring items where possible.

Capital spending in the U.S. chemical industry is completely becalmed and will stay that way at least through 1982. Many basic chemical companies have pruned already modest spending plans for new plant and equipment under the weight of a severe, continuing recession. But even before the recession, chemical capital spending had geared down notably from its frenetic pace in the mid-1970s. This year is the fifth in a row of low capital spending relative to industry sales.

An update of C&EN's annual worldwide capital spending survey of 17 major U.S. basic chemical companies finds a mere 1% increase now planned for 1982 over 1981—to $8.27 billion. Six months ago, the planned increase for 1982 was 6%. With inflation stripped out, the new figure guarantees an actual drop from 1981. Revised data for 1981 now show just a 5% increase over 1980, down from 9% foreseen a year ago.

The government's capital spending surveys for the broader category of chemical and allied products companies find a somewhat more expansive prospect. For U.S. spending, the Commerce Department's regular surveys show a planned increase of 13% in 1982 to $15.38 billion after an 8% gain to $13.60 billion in 1981. For spending by wholly owned foreign affiliates of U.S. chemical firms, Commerce finds a planned increase of 29% in 1982 to $4.0 billion. However, the original increase in foreign spending planned a year ago for 1981 was trimmed to just 3% by the end of the year.

For perspective, the cyclical trough in basic chemical companies' capital spending becomes quite clear by comparison with sales. Spending as a percentage of sales, which has peaked at about 14% in the past decade, is down to a low 9.7% for 1982, C&EN estimates. The figure for 1981 also was low at 10.1%.

The capital spending lull in chemicals has reached the point that unspent project backlogs at year's end eased in 1981 after climbing substantially in 1979 and 1980, according to surveys by the Conference Board. This means an end to the surplus of appropriations over spending which had characterized hopeful industry plans at the turn of the decade.

It wasn't supposed to be quite this quiet on the capital spending front in 1982, although industry forecasts in the past few years have leaned toward restraint. The three-year pause in the industry's basic growth since 1979 simply has thrown off a lot of investment schedules, creating much more unused plant capacity this year than thought earlier. Add to this a decided industry switch toward development of more specialized, less capital-intensive products. The result for 1982 is a near halt to increases in the chemical industry's largest use of funds after paying ordinary operating expenses and taxes.

CHEMICAL CAPITAL SPENDING: Leading chemical firms hold funding nearly flat in 1982

$ Millions	1982[a]	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972
Air Products	$ 400	$ 323	$ 364	$ 246	$ 200	$ 143	$ 162	$ 151	$ 110	$ 67	$ 42
Akzona	68	60	64	54	42	35	38	51	57	42	43
Allied	700	609	533	409	502	465	352	314	306	194	128
American Cyanamid	185	181	196	235	251	235	232	204	139	83	72
Celanese	400	414	253	245	248	243	223	208	220	159	128
Diamond Shamrock	540	521	387	266	319	390	334	183	201	103	61
Dow Chemical	950	1176	1184	1268	1075	1163	1200	935	890	415	359
Du Pont[b]	1400	1420	1297	864	714	704	876	1036	1008	781	561
Ethyl	120	141	156	123	96	88	88	69	75	35	32
W. R. Grace	700	657	658	514	313	279	234	309	303	174	135
Hercules	200	167	229	186	116	127	150	151	217	144	80
Monsanto	660	6[illegible]8	781	566	480	607	647	528	313	205	168
Olin	160[c]	186	172	161	163	208	166	99	67	78	76
Pennwalt	100	53	53	65	61	45	40	32	43	25	22
Rohm & Haas	175	182	93	68	66	79	110	106	106	73	62
Stauffer Chemical	215	239	246	239	201	193	199	199	83	45	35
Union Carbide	1300	1186	1129	831	688	805	965	862	517	289	244
TOTAL	**$8273**	**$8183**	**$7795**	**$6340**	**$5535**	**$5809**	**$6016**	**$5437**	**$4655**	**$2912**	**$2248**
ANNUAL CHANGE	1%	5%	23%	15%	−5%	−3%	11%	17%	60%	30%	−6%

a Planned. **b** Excludes Conoco. **c** C&EN estimate. **Note:** Figures are for worldwide spending on construction, equipment, and land in consolidated businesses. Where possible, acquisition costs and investments in nonconsolidated businesses are excluded. **Sources:** Company data, C&EN estimates

INDUSTRY CAPITAL SPENDING: Budgets still increase for chemicals and allied products

$ Billions	1982[a]	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972
Chemicals	$ 15.38	$ 13.60	$ 12.60	$10.78	$ 8.46	$ 8.14	$ 8.12	$ 7.63	$ 6.48	$ 4.24	$ 3.38
Iron and steel	4.07	3.17	3.29	3.09	2.52	2.79	3.04	3.03	1.94	1.25	1.06
Nonferrous metals	2.95	3.46	3.11	2.39	2.11	1.88	1.97	2.18	2.04	1.30	0.97
Paper	6.75	6.72	6.80	5.55	3.99	3.59	3.11	2.98	2.90	2.00	1.45
Petroleum	28.96	26.56	20.69	16.21	13.95	12.70	10.76	9.59	7.31	4.68	4.80
Rubber	2.03	1.77	1.73	2.17	2.10	1.66	1.32	1.15	1.56	1.55	1.03
Stone, clay, glass	3.18	3.14	3.82	3.94	3.10	2.23	1.88	1.67	1.64	1.58	1.33
All manufacturing	136.81	126.79	115.81	98.68	79.72	69.22	59.95	54.92	53.21	42.37	35.42

a Estimate. **Source:** Department of Commerce

Backlogs of unspent chemical capital funds receded in 1981

$ Billions	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971
Chemicals	$ 9.5	$ 9.8	$ 8.5	$ 7.2	$ 7.4	$ 7.1	$ 6.9	$ 6.6	$ 4.9	$ 2.9	$ 2.3
Iron and steel	5.5	3.9	4.5	4.0	3.6	4.7	5.4	5.8	2.4	1.9	1.8
Nonferrous metals	3.3	3.7	2.9	2.7	2.9	2.4	2.2	2.7	2.2	1.1	0.7
Paper	4.7	4.0	4.2	3.2	2.6	2.0	2.7	2.9	1.7	1.1	0.8
Petroleum, coal	29.7	26.7	16.1	14.6	15.0	12.2	14.1	12.8	7.1	4.3	3.8
Rubber	1.0	1.0	0.9	0.9	0.8	0.7	0.6	0.7	0.9	0.8	0.5
Stone, clay, glass	2.1	2.0	2.3	2.4	2.0	1.5	1.4	1.7	1.5	0.8	0.5
All manufacturing	92.0	91.9	76.7	63.4	56.5	47.5	46.4	49.8	37.1	23.3	18.9

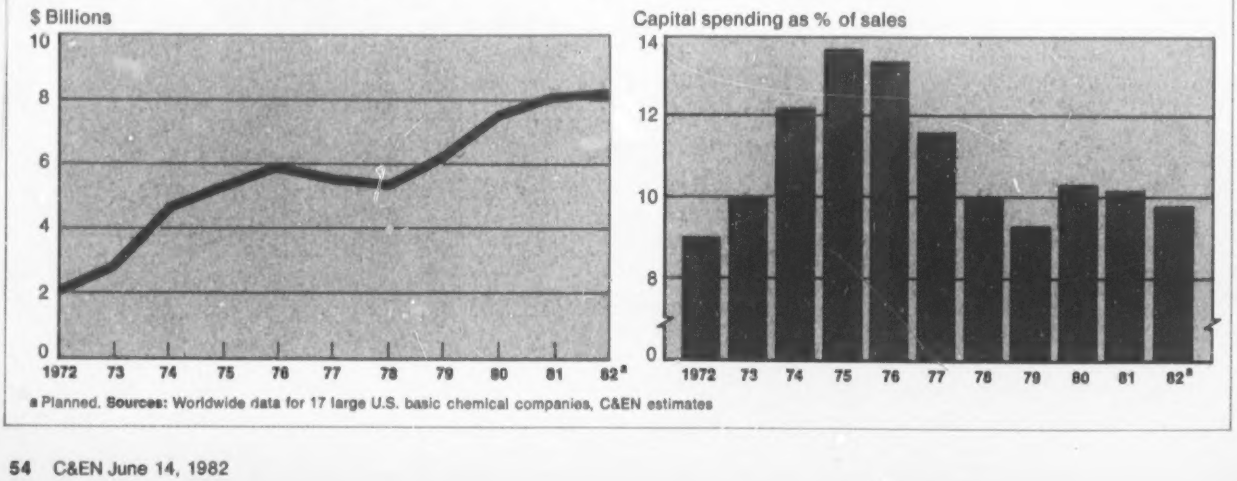
Note: Figures are for fourth quarter each year. **Source:** Conference Board

Chemical capital spending continues to increase outside U.S.

$ Billions[a]	1982[b]	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972
Chemicals and allied products	$ 4.0	$ 3.1	$ 3.0	$ 2.6	$ 1.9	$ 2.0	$ 2.7	$ 2.5	$ 2.1	$1.4	$1.2
Metals, primary and fabricated	1.5	1.0	0.9	0.6	0.6	0.5	0.7	0.7	0.7	0.8	0.6
All manufacturing	21.4	19.5	19.5	15.4	12.0	10.5	10.9	11.3	11.6	9.2	7.2
Petroleum	20.5	17.5	14.8	11.0	9.5	8.9	7.9	8.9	7.8	6.4	5.2

a By majority-owned affiliates of U.S. companies; data after 1973 are not consistent with earlier years. b Planned. **Source:** Department of Commerce

Chemical capital spending hits plateau, falls again relative to sales



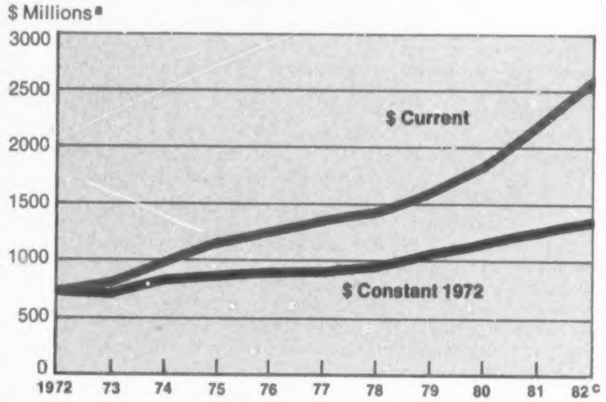
a Planned. **Sources:** Worldwide data for 17 large U.S. basic chemical companies, C&EN estimates

In ever more marked contrast to the weak state of capital spending, research and development support in the U.S. chemical industry is booming. In an astonishing show of support for a deep recession year, the 15 major U.S. basic chemical companies in C&EN's regular survey plan to push R&D spending up 18% over 1981. This follows increases of 20% in 1981, 17% in 1980, and 12% in 1979. That means that these companies' R&D outlays have mushroomed 84% in just four years to an expected \$2.6 billion in 1982.

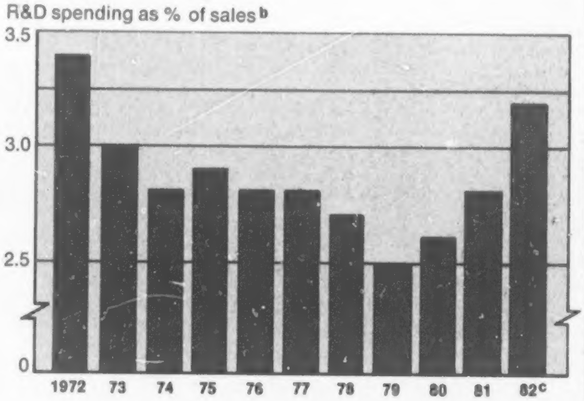
This is truly one of the golden periods for R&D, which is enjoying enormous corporate support. Underneath, companies have decided that they must move quickly to develop sophisticated, largely specialized products for the 1980s. Reasons are that big growth has ended for the bulk chemicals and polymers developed in the 1950s and 1960s, patent protection is ending for many specialties, and foreign competition has increased greatly.

The R&D spending increases in the four most recent years comfortably outstrip inflation in R&D costs and hence allow real increases in staffs and projects. R&D employment has expanded steadily and promises to stay strong. For 1982, companies forecast an increase in R&D funds that is more than twice the 8% inflation rate estimated by Battelle Columbus Laboratories for costs of doing R&D.

Chemical R&D funds also are fast regaining their old position relative to industry sales. R&D spending had fallen from 3.4% of sales in 1972 to a low of 2.5% in 1979. Since then, however, the figure has recovered most of the ground and could reach 3.2% of sales this year, C&EN estimates.



R&D funding by chemical companies continues to outpace inflation . . .



. . . and easily will rise again relative to company sales

a R&D spending by basic chemical companies. b By basic chemical companies. c Estimate. **Sources:** Worldwide data for 15 U.S. basic chemical companies, Battelle Columbus Laboratories, C&EN estimates

CHEMICAL R&D SPENDING: More strong increases are budgeted in 1982

$ Millions	1982[a]	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972
Air Products	$ 35	$ 32	$ 30	$ 24	$ 23	$ 24	$ 19	$ 16	$ 11	$ 8	$ 7
Akzona	36	32	28	25	23	20	18	17	16	13	11
Allied	198	152	105	70	56	51	40	35	31	29	29
American Cyanamid	180	164	142	124	108	96	83	73	64	52	44
Celanese	118	104	94	92	83	77	70	64	58	49	52
Diamond Shamrock	64	53	45	37	32	26	24	20	14	12	12
Dow Chemical	500	404	314	269	232	203	188	167	149	118	105
Du Pont[b]	670	575	485	415	377	367	353	336	344	286	265
W. R. Grace	65	55	45	42	37	32	28	30	32	28	22
Hercules	66	61	53	47	40	37	35	30	30	25	24
Monsanto[c]	260	221	204	161	136	132	114	116	87	82	92
Pennwalt	34	27	24	22	23	21	19	16	14	13	18
Rohm & Haas	90	77	67	54	49	45	43	45	39	32	25
Stauffer Chemical	60	51	44	37	34	33	29	24	20	17	14
Union Carbide	222	201	166	161	156	156	143	120	94	77	70
TOTAL	**$2598**	**$2209**	**$1846**	**$1580**	**$1409**	**$1320**	**$1206**	**$1109**	**$1003**	**$841**	**$790**
ANNUAL CHANGE	**18%**	**20%**	**17%**	**12%**	**7%**	**9%**	**9%**	**11%**	**19%**	**6%**	**2%**

a Planned. b Excludes Conoco. c R&D definition narrowed after 1972. **Sources:** Company data, C&EN estimates

2 Finances of the U.S. Chemical Industry

Chemical companies clearly were keeping a close watch on operating expenses last year. As a result, for a year when many segments of U.S. industry were awash with red ink, profit-and-loss statements in the chemical industry looked comparatively favorable, by and large.

In fact, more than twice as many of the major chemical companies listed on this and the following pages—which present financial results for 48 leading chemical and pharmaceutical firms covering the past four years—were able to report higher earnings during 1981 than watched earnings decline. The comparison, to be sure, is against a year, 1980, when profits were depressed for many companies. Thus, profits were higher for companies like Du Pont, Monsanto, Celanese, and Akzona, in part because their synthetic fibers business was not the disaster last year that it had been the year before. Akzona's earnings still were far below those of 1979, despite last year's improvement, and Du Pont's profits would have been lower were it not for its merger with Conoco.

Profitability, too, held up relatively well, all things considered. About half of the chemical companies increased their margin on sales in 1981 from the year before. Half, too (although not in every case the same firms), had a higher return on net worth.

Companies also were more generous to their stockholders. Three quarters of them increased their dividends in 1981. Only one, Reichhold, paid out less last year.

Explanation of table headings

Year. Data are for calendar year unless otherwise indicated.

Net sales. Gross sales, less discounts, allowances, and returns; generally excludes excise taxes and other operating income or revenues.

Net income. Net sales and other income, less operating costs, nonoperating charges, depreciation, depletion, interest expense, deferred charges, minority interest in income, and taxes. Nonrecurring or extraordinary credits and charges have been excluded in most cases, but these items are indicated by a footnote.

Total assets. Sum at year's end of current assets, investments, prepaid expenses, net plant and equipment, and other tangible assets. Excludes insofar as possible intangible assets including goodwill, value of patents and trademarks, and the like.

Current ratio. The ratio of current assets (cash, marketable securities, receivables, and inventories but excluding prepaid expenses) to total current liabilities.

Net plant and equipment. Value at year's end of fixed assets, less accumulated depreciation, amortization, and depletion.

Capital expenditures. Total spending during the year for new fixed assets, such as plant, equipment, and land, and for replacement and modernization of facilities.

Net worth. Equity at year's end of preferred and common stock holders, including value of capital stock, capital and earned surplus, and surplus reserves, as well as contingency and miscellaneous reserves for which no definite purpose is stated. Intangible assets are deducted insofar as possible.

Net income (breakdown). **Per cent of sales:** net income divided by net sales. **Per cent of net worth:** net income divided by tangible net worth. **Dollars per share:** net income, less preferred dividends, divided by the number of shares of common stock outstanding. All figures are adjusted for stock splits, but no adjustment has been made for earlier years as a result of stock dividends or for dilution that might result from the conversion of preferred stock or debt to common stock or the exercise of stock options outstanding.

Dividends per share. Cash dividends paid (or declared) on each share of common stock; excludes the value of stock dividends, which are indicated by a footnote.

Dividend yield. Dividends per share divided by the average of the high and low prices of the common stock during the calendar year.

Stock price range. High-low market prices of common stock during the calendar year, adjusted for stock splits but not for stock dividends.

Price-earnings ratio. Average of the high and low prices of the common stock during the calendar year divided by net income per share of common stock.

Money figures in thousands of dollars unless otherwise indicated

Year	Net sales	Net income	Total assets	Current ratio	Net plant and equipment	Capital expenditures	Net worth	NET INCOME			Dividends, $ per share	Dividend yield, % of price	Stock price range, $ per share	Price-earnings ratio
								% of sales	% of net worth	$ per share				
CHEMICALS														
Air Products & Chemicals														
1981[a]	$1,570,115	$126,039	$1,871,986	1.2	$1,301,922	$323,465	$769,134	8.0%	16.4%	$4.42	$0.80	1.9%	$48⅞–34	9.4
1980[a]	1,420,759	115,502	1,744,392	1.3	1,182,567	364,013	658,596	8.1	17.5	4.07	0.80	1.8	54¼–32¼	10.6
1979[a]	1,229,894	97,540	1,415,024	1.3	945,013	246,050	563,702	7.9	17.3	3.45	0.65	2.1	37¼–23¾	8.8
1978[a]	1,039,052	76,184	1,180,754	1.2	801,809	199,847	477,557	7.3	16.0	2.70	0.50	1.8	31⅞–22½	10.1
Akzona														
1981	$1,187,583	$11,598	$836,090	2.1	$409,846	$59,507	$320,033	1.0%	3.6%	$0.95	$0.80	6.5%	$15½–9¼	13.0
1980	1,054,015	4,877	846,708	2.1	412,039	64,313	319,139	0.5	1.5	0.40	0.80	6.3	17½–7¾	31.6
1979	1,012,398	25,647	818,125	2.2	402,178	54,486	323,875	2.5	7.9	2.10	0.80	5.6	17⅛–11¼	6.8
1978	868,711	20,832	704,095	2.5	374,065	42,404	307,790	2.4	6.8	1.69	0.80	6.0	15¼–11¼	7.8
Allied Corp.														
1981	$6,407,000	$343,000[b]	$5,205,000	1.4	$2,866,000	$609,000	$2,352,000	5.4%	14.6%	$9.03[b]	$2.35	4.8%	$59⅞–39	5.5
1980	5,519,000	303,000[c]	4,475,000	1.3	2,384,000	533,000	1,861,000	5.5	16.3	8.59[c]	2.15	4.3	61¾–39	5.9
1979	4,332,391	201,080[d]	4,159,798	1.1	2,168,816	408,668	1,377,701	4.6	14.6	6.84[d]	2.00	5.1	49½–28½	5.7
1978	3,267,956	124,557[e]	3,182,335	1.4	2,041,409	502,040	1,226,710	3.8	10.2	4.40[e]	2.00	5.5	44¾–27⅝	8.2
American Cyanamid Co.														
1981	$3,649,073	$197,054	$3,049,917	1.9	$1,325,063	$180,697	$1,513,457	5.4%	13.0%	$4.11	$1.675	5.5%	$36½–24½	7.4
1980	3,453,934	159,195	2,900,289	1.8	1,328,681	195,819	1,419,073	4.6	11.2	3.32	1.60	5.5	38–20⅝	8.8
1979	3,186,998	168,495	2,810,725	1.6	1,303,308	235,416	1,331,130	5.3	12.7	3.52	1.60	5.3	36⅛–23¾	8.5
1978	2,780,170	155,943	2,510,038	1.8	1,212,807	251,034	1,238,396	5.6	12.6	3.26	1.50	5.4	32⅞–22⅝	8.5

a Fiscal year ends Sept. 30. b Excludes nonrecurring net gain of $5 million ($0.14 per share). c Excludes nonrecurring net loss from estimated plant shutdown and disposal costs of $14 million ($0.44 per share). d From continuing operations; excludes net losses from discontinued businesses of $164.8 million ($5.75 per share) and nonrecurring net loss of $25.4 million ($0.89 per share). e Excludes nonrecurring net loss from sales of plants of $4.3 million ($0.15 per share).

Money figures in thousands of dollars unless otherwise indicated

								NET INCOME						
Year	Net sales	Net income	Total assets	Current ratio	Net plant and equipment	Capital expenditures	Net worth	% of sales	% of net worth	$ per share	Dividends, $ per share	Dividend yield, % of price	Stock price range, $ per share	Price-earnings ratio
Big Three Industries														
1981	$823,280	$108,854	$1,015,259	2.7	$680,709	$158,234	$555,765	13.2%	19.6%	$2.57	$0.60	1.9%	$37⅝–25	12.2
1980	659,121	86,604	815,048	2.2	583,772	142,542	472,607	13.1	18.3	2.05	0.47[a]	1.7	36⅛–18⅞	13.4
1979	509,449	62,659	700,052	2.3	488,921	79,710	404,137	12.3	15.6	1.56	0.42	2.2	22¼–15¾	12.2
1978	428,934	56,718	604,437	2.2	448,707	93,374	357,478	13.2	15.9	1.41	0.34	2.0	20¼–14/12	12.3
Cabot Corp.														
1981[b]	$1,622,755	$110,167	$2,497,633	2.2	$595,234	$192,348	$586,226	6.8%	18.8%	$3.50	$0.86	2.9%	$35½–23⅞	8.5
1980[b]	1,403,743	94,024[c]	1,138,683	2.0	456,507	117,705	497,546	6.7	18.9	3.00[c]	0.67	2.6	36⅜–14¾	8.5
1979[b]	1,122,391	70,445	918,431	2.0	401,638	68,266	358,031	6.3	19.7	2.28	0.47	3.5	16⅝–10⅛	5.9
1978[b]	713,136	46,500	752,089	2.5	353,020	111,902	303,542	6.5	15.3	1.53	0.35	3.5	12⅞–7	6.5
Celanese Corp.														
1981	$3,752,000	$144,000	$2,991,000	2.0	$1,518,000	$414,000	$1,233,000	3.8%	11.7%	$9.01	$3.85	6.4%	$69¼–51⅝	6.7
1980	3,348,000	122,000	2,633,000	2.0	1,197,000	253,000	1,101,000	3.6	11.1	8.20	3.50	6.8	62⅝–39⅞	6.2
1979	3,146,000	141,000	2,374,000	1.8	1,150,000	245,000	1,033,000	4.5	13.6	9.52	3.10	7.0	48¾–39⅜	4.6
1978	2,609,000	112,000[d]	2,[illegible]49,000	2.0	1,148,000	248,000	936,000	4.3	12.0	7.61[d]	2.85	6.9	47⅛–35⅝	5.4
Crompton & Knowles Corp.														
1981	$243,412	$8,571	$132,197	2.3	$32,668	$6,699	$63,606	3.5%	13.5%	$2.51	$0.95	6.1%	$18⅛–12⅞	6.2
1980	241,776	7,666	135,619	2.5	34,731	9,623	58,935	3.2	13.0	2.22	0.80	5.8	16⅝–10⅞	6.2
1979	239,638	7,075	131,433	2.2	28,822	7,895	55,212	3.0	12.8	2.03	0.69	6.6	12¼–8⅝	5.1
1978	217,412	6,137	127,177	2.3	25,110	4,484	49,699	2.8	12.3	1.77	0.64	6.1	12⅝–8⅜	6.0
Diamond Shamrock Corp.														
1981	$3,376,215	$230,156[e]	$2,933,550	1.9	$1,726,458	$520,917	$1,266,900	6.8%	18.2%	$3.68[e]	$1.70	5.4%	$39⅝–23¾	8.6
1980	3,143,040	201,214	2,707,284	2.1	1,600,250	381,036	1,155,950	6.4	17.4	3.66	1.62	5.2	38⅞–23⅛	8.5
1979	2,356,858	178,123	2,329,892	1.9	1,382,931	256,564	931,267	7.6	19.1	3.37	1.51	6.0	31½–19	7.5
1978	1,677,602	131,063	1,969,509	1.9	1,294,970	286,843	790,555	7.8	16.6	3.26	1.42	5.8	29¾–19	7.5
Dow Chemical Co.														
1981	$11,873,000	$564,000	$12,268,000	1.7	$6,174,000	$1,176,000	$4,663,000	4.8%	12.1%	$3.00	$1.80	5.8%	$ 39–23⅜	10.4
1980	10,626,000	753,000[f]	11,429,000	1.5	5,672,000	1,184,000	4,331,000	7.1	17.4	4.14[f]	1.60	4.7	39¼–28¼	8.2
1979	9,255,387	734,000[g]	10,144,745	1.4	5,236,404	1,267,719	3,789,746	7.9	19.4	4.05[g]	1.45	4.9	34⅞–24⅜	7.3
1978	6,887,623	575,224	8,705,081	1.6	4,762,129	1,075,173	3,310,655	8.4	17.4	3.16	1.25	4.7	30⅞–22	8.4
E. I. du Pont de Nemours & Co.														
1981	$22,810,000	$1,081,000[h]	$23,829,000	2.0	$12,722,000	$2,389,000	$10,458,000	4.7%	10.3%	$5.81[h]	$2.75	6.0%	$ 56–35¾	7.9
1980	13,652,000	716,000	9,560,000	2.3	4,414,000	1,279,000	5,690,000	5.2	12.6	4.83	2.75	6.8	49½–31⅛	8.3
1979	12,571,800	938,900	8,918,700	2.5	3,942,400	864,000	5,290,600	7.5	17.7	6.42	2.75	6.5	48¼–37	6.6
1978	10,584,200	787,000	8,047,700	2.3	3,839,000	714,200	4,737,800	7.4	16.6	5.39	2.42	6.1	46⅛–32½	7.3
Ethyl Corp.														
1981	$1,757,195	$90,891	$1,194,630	2.2	$658,282	$140,520	$683,001	5.2%	13.3%	$4.56	$1.50	5.3%	$34½–21⅞	6.2
1980	1,740,627	82,397[i]	1,138,233	2.4	602,029	156,388	631,831	4.7	13.0	4.11[i]	1.50	5.1	36½–22¼	7.1
1979	1,656,977	97,515	1,070,968	2.8	512,901	122,878	536,671	5.9	18.2	4.94	1.35	5.3	30–21	5.2
1978	1,422,451	82,698	1,001,584	2.9	446,346	95,803	514,693	5.8	16.1	4.24	1.10	5.1	24⅞–18½	5.1
Ferro Corp.														
1981	$702,213	$25,503	$389,405	2.1	$135,587	$24,243	$222,441	3.6%	11.5%	$3.30	$1.20	4.6%	$31½–20¾	7.9
1980	695,580	29,019	430,472	2.0	134,563	31,505	220,597	4.2	13.2	3.77	1.20	5.8	24¼–17	5.5
1979	591,930	30,912	387,703	1.8	115,831	33,132	200,625	5.2	15.4	4.07	1.14	4.7	29⅜–19	5.9
1978	494,414	27,657	310,612	2.0	86,805	19,385	175,618	5.6	15.7	3.67	1.05	4.0	35–17⅛	7.1
First Mississippi Corp.														
1981[j]	$357,697	$29,704	$318,926	1.5	$117,244	$58,277	$138,384	8.3%	21.5%	$1.38	$0.23	1.2%	$26⅛–13⅛	14.2
1980[j]	242,690	21,154	236,579	2.1	83,525	37,202	113,672	8.7	18.6	0.98	0.18	0.9	30¾–7½	19.5
1979[j]	178,400	4,661	200,370	2.8	63,942	17,046	95,073	2.6	4.9	0.22	0.16	2.0	11¾–4	35.8
1978[j]	155,525	4,170	205,837	2.9	72,190	12,558	93,528	2.7	4.5	0.20	0.16	3.2	6⅝–3¼	25.0
W. R. Grace & Co.														
1981	$6,520,800	$361,300[k]	$4,947,100	1.5	$2,528,600	$656,900	$1,986,600	5.5%	18.2%	$7.58[k]	$2.45	5.0%	$59⅝–38½	6.5
1980	6,101,300	283,800[l]	4,281,500	1.5	2,162,700	657,400	1,713,100	4.7	16.6	6.08[l]	2.175	4.5	63½–32⅝	7.9
1979	5,266,629	222,580[m]	3,680,847	1.6	1,629,361	477,688	1,524,276	4.2	14.6	5.02[m]	1.975	5.9	41¼–25⅝	6.7
1978	4,309,588	170,403[n]	3,201,126	1.9	1,317,159	275,308	1,333,772	4.0	12.8	4.23[n]	1.85	6.6	32⅜–23¾	6.6
Great Lakes Chemical Corp.														
1981	$150,333	$18,031	$170,198	1.9	$98,580	$22,777	$108,878	12.0%	16.6%	$2.51	$0.44	0.9%	$58½–36¼	18.9
1980	126,705	18,948	118,407	3.2	61,747	20,496	93,258	15.0	20.3	2.67	0.36	0.8	51¼–35⅝	16.3
1979	122,491	15,606	99,323	2.8	48,802	18,315	75,457	15.2	24.7	2.65	0.28	0.9	39¼–22½	11.7
1978	87,435	13,276	78,762	2.8	36,229	8,515	57,800	15.2	23.0	1.92	0.205	1.0	25½–14¾	10.5

a Plus 5% stock dividend. **b** Fiscal year ends Sept. 30. **c** From continuing operations; excludes net income from discontinued operations of $12.3 million ($0.39 per share) and gain on sale of machinery division of $46.4 million ($1.49 per share). **d** Excludes cumulative effects of change in accounting for investment tax credits of $[illegible]3 million ($3.01 per share). **e** From continuing operations; excludes net loss from operations and disposal of plastics and animal nutrition businesses of $108.9 million ($1.74 per share). **f** Excludes net gain on sale of Wanda Petroleum Co. of $52 million ($0.28 per share). **g** Excludes net gain on sale of Canadian oil and gas properties of $50 million ($0.28 per share). **h** Excludes cumulative effects of change in accounting for investment tax credits of $320 million ($1.74 per share). **i** Excludes net capital gain on sale of property of $7.3 million ($0.38 per share). **j** Fiscal year ends June 30. **k** Includes net gains on disposal of businesses of $31.1 million. **l** Includes net losses on disposal of businesses of $10.3 million. **m** Includes net gains on disposal of businesses of $5.2 million. **n** Includes net gains on disposal of businesses of $8.0 million.

								NET INCOME						
Year	Net sales	Net income	Total assets	Current ratio	Net plant and equipment	Capital expenditures	Net worth	% of sales	% of net worth	$ per share	Dividends, $ per share	Dividend yield, % of price	Stock price range, $ per share	Price-earnings ratio
	Money figures in thousands of dollars unless otherwise indicated													
Hercules														
1981	$2,718,366	$135,481	$1,997,144	2.5	$907,733	$167,189	$1,051,357	5.0%	13.0%	$3.09	$1.26	5.6%	$26⅜–18¾	7.3
1980	2,485,226	114,000	1,889,679	2.0	872,656	229,163	1,009,746	4.6	11.3	2.60	1.20	6.0	25–15⅛	7.7
1979	2,345,425	144,500[a]	1,761,177	1.9	772,889	185,998	945,422	6.2	15.3	3.27[a]	1.075	5.5	22¾–16⅛	5.9
1978	1,946,477	103,264[b]	1,590,306	1.9	714,286	115,807	812,159	5.3	12.7	2.36[b]	1.00	6.5	18⅝–12¼	6.5
Philip A. Hunt Chemical Corp.														
1981	$111,871	$3,816[c]	$87,238	2.6	$36,231	$9,105	$56,005	3.4%	6.8%	$0.67[c]	$0.40	3.9%	$12⅛–8½	15.4
1980	106,296	4,044[d]	78,020	3.0	32,376	6,930	56,788	3.8	7.1	0.71[d]	0.40	3.5	14¼–8½	16.0
1979	106,004	8,015	72,794	3.4	29,067	9,206	55,606	7.6	14.4	1.41	0.40	2.9	17–11	9.9
1978	91,347	7,455	66,467	3.8	22,564	3,885	49,993	8.2	15.3	1.31	0.37	2.9	15¾–10	9.8
International Flavors & Fragrances														
1981	$451,088	$66,123	$430,890	3.8	$125,975	$16,558	$329,878	14.7%	20.0%	$1.81	$0.94	4.6%	$ 23–17⅞	11.3
1980	448,309	63,232	414,859	3.8	121,228	17,461	315,485	14.1	20.0	1.73	0.86	3.9	27½–16⅝	12.8
1979	409,299	61,472	387,807	3.6	114,255	15,180	285,425	15.0	21.5	1.68	0.74	3.4	25⅝–18¼	13.1
1978	365,881	56,199	345,073	3.4	109,092	20,014	252,706	15.4	22.2	1.53	0.59	2.5	27⅝–19⅝	15.4
International Minerals & Chemical Corp.														
1981	$1,984,900	$153,800	$1,975,200	1.7	$1,896,300	$336,600	$975,300	7.7%	15.8%	$5.63	$2.46	5.1%	$66½–30⅜	8.6
1980[e]	1,789,600	145,900	1,848,600	2.0	1,062,900	262,100	881,300	8.2	16.6	5.38	2.16	4.5	66½–30	9.0
1979[e]	1,474,700	120,800	1,537,600	1.7	936,600	173,500	790,200	8.2	15.3	4.48	1.87	5.8	41–23½	7.2
1978[e]	1,364,400	120,100	1,461,900	1.9	879,400	193,600	721,000	8.8	16.7	4.41	1.73	6.7	29–22⅝	5.9
Liquid Air Corp.														
1981	$427,991	$31,526[f]	$465,128	1.6	$285,026	$61,818	$239,776	7.4%	13.1%	$2.86[f]	$1.55	6.7%	$29¾–16¾	8.1
1980	408,249	27,448[g]	425,502	1.6	270,778	60,469	202,832	6.7	13.5	2.57[g]	1.40	5.2	34½–19¾	10.6
1979	369,109	24,698	399,354	1.7	259,006	50,714	191,641	6.7	12.9	2.49	1.40	5.3	28¾–23¾	10.5
1978	304,266	18,346	299,419	1.8	180,327	37,092	121,097	6.0	15.1	2.48	1.40	5.2	30½–23½	10.9
Lubrizol Corp.														
1981	$878,291	$ 92,031	$673,165	2.6	$284,089	$75,399	$478,518	10.5%	19.2%	$2.36	$1.08	3.9%	$35½–20⅜	11.8
1980	902,312	111,511	651,137	2.5	248,664	92,140	452,787	12.4	24.6	2.87	0.90	2.7	41¾–24⅞	11.6
1979	724,734	90,775	519,942	2.5	180,405	50,807	374,751	12.5	24.2	2.33	0.80	3.2	30–20½	10.8
1978	586,477	77,365	441,735	2.8	150,018	44,373	323,036	13.2	23.9	1.97	0.70	3.4	24⅛–16¾	10.3
Monsanto Co.														
1981	$6,947,700	$445,100[h]	$6,069,200	2.2	$3,183,900	$667,900	$3,330,200	6.4%	13.4%	$11.50	$3.75	5.1%	$87½–59½	6.4
1980	6,573,600	148,800[i]	5,796,400	1.9	3,109,100	780,500	2,808,200	2.3	5.3	4.10[i]	3.55	6.3	70¼–42¼	13.7
1979	6,192,600	331,000[j]	5,539,100	2.2	2,817,800	565,900	2,781,800	5.3	11.9	9.11[j]	3.35	6.3	62–45	5.9
1978	5,018,700	302,600[k]	5,035,700	2.5	2,604,800	479,900	2,579,400	6.0	11.7	8.29[k]	3.175	6.1	60¼–44⅛	6.3
Nalco Chemical Co.														
1981	$666,591	$81,209	$466,175	2.2	$176,959	$59,423	$335,974	12.2%	24.2%	$2.02	$1.00	4.0%	$29⅛–20½	12.3
1980	616,709	72,261	416,233	2.7	138,137	34,923	306,550	11.7	23.6	1.80	0.80	3.9	26⅝–14	11.2
1979	578,908	63,277	368,074	2.5	126,774	39,018	261,966	10.9	24.2	1.59	0.68	4.4	17⅝–13⅛	9.7
1978	476,208	53,652[l]	309,666	2.5	105,197	34,278	221,814	11.3	24.2	1.35[l]	0.62	4.3	16⅜–12¼	10.5
Olin Corp.														
1981	$2,001,346	$92,836	$1,618,034	1.6	$844,927	$186,331	$793,187	4.6%	11.7%	$3.88	$1.15	4.9%	$ 27–19½	6.0
1980	1,852,853	73,931[m]	1,550,128	1.7	822,412	172,016	750,120	4.0	9.9	3.08[m]	1.025	5.8	23⅛–12½	5.8
1979	1,778,102	71,150	1,461,073	1.7	764,108	161,151	739,992	4.0	9.6	2.97	0.97	4.7	25–16⅛	6.9
1978	1,560,075	62,769	1,393,064	1.7	742,158	162,519	691,563	4.0	9.1	2.62	0.88	4.5	25¾–13⅜	7.5
Pennwalt Corp.														
1981	$1,056,118	$36,661[n]	$755,755	2.1	$309,525	$52,696	$367,098	3.5%	10.0%	$3.55[n]	$2.20	7.1%	$ 36–26¼	8.8
1980	1,188,702	43,291	810,761	2.0	314,315	55,546	373,363	3.6	11.6	4.20	2.20	7.4	34⅜–25⅜	7.1
1979	1,079,303	49,997	775,355	2.1	298,420	67,486	346,140	4.6	14.4	5.01	2.20	6.1	35⅞–30½	6.6
1978	921,369	44,973	672,343	2.1	270,374	61,938	317,073	4.9	14.2	4.54	2.00	5.4	42½–31½	8.1
Reichhold Chemicals														
1981	$950,112	$17,054[o]	$405,477	2.3	$173,398	$15,908	$206,727	1.8%	8.2%	$2.04[o]	$0.48	3.5%	$ 16–11⅛	6.6
1930	885,059	16,114	424,760	2.1	179,550	22,656	203,941	1.8	7.9	1.90	0.61	5.0	15–9⅝	6.5
1979	874,854	12,230	425,478	2.0	179,960	26,114	194,619	1.4	6.3	1.34	0.74	5.4	16–11¼	10.2
1978	753,885	12,038[p]	393,433	2.0	173,791	24,287	190,493	1.6	6.3	1.32[p]	0.74	5.4	16½–11	10.4
Rohm & Haas Co.														
1981	$1,884,664	$93,085[q]	$1,348,627	2.4	$537,489	$181,635	$759,911	4.9%	12.2%	$7.21[q]	$2.56	4.3%	$71¾–46¾	8.2
1980	1,725,304	93,744	1,240,456	2.6	488,185	93,013	703,124	5.4	13.3	7.26	2.16	4.9	55¼–32¾	6.1
1979	1,590,484	95,495[r]	1,191,903	2.3	487,841	68,328	637,398	6.0	15.0	7.39[r]	1.76	4.4	48½–31½	5.4
1978	1,253,543	57,798[s]	1,074,656	2.3	464,335	66,431	557,511	4.6	10.4	4.49[s]	1.40	4.1	40¼–28⅛	13.1

a Excludes net gain on sale of pigments and methanol assets of $28.0 million ($0.62 per share). **b** Includes net loss from write-down of facilities of $4.9 million ($0.11 per share). **c** From continuing operations; excludes net loss on disposal of photofinishing business of $146,000 ($0.03 per share). **d** From continuing operations; excludes net loss on operations and disposal of photofinishing business of $1.9 million ($0.33 per share). **e** Fiscal year ends June 30. **f** Includes gain on sale of assets, before taxes, of $1.0 million. **g** Excludes net gain on sale of assets of $2.0 million ($0.19 per share). **h** Includes net gain on sale of joint venture of $67.7 million ($1.75 per share). **i** Includes net loss on withdrawal from polyester filament business in the U.S. of $69.0 million ($1.90 per share) and from termination of interest in Aiscondel of $38.7 million ($1.07 per share). **j** Includes nonrecurring net charges for shutdown of European businesses of $53.2 million ($1.47 per share). **k** Includes net gain from divestiture of various businesses of $8.7 million. **l** From continuing operations; excludes net loss from discontinued Scientific Services operations of $14.5 million ($0.73 per share). **m** Excludes net charge for restructuring of Winchester group of $40.0 million ($1.07 per share). **n** From continuing operations; includes cost of shutdown of chlorine-caustic plant, before taxes, of $21.5 million but excludes net loss on operations and disposal of discontinued businesses of $11.4 million ($1.10 per share) and nonrecurring net gain from cumulative effect of change in accounting for investment credit of $16.3 million ($1.57 per share). **o** Excludes net extraordinary charge for settlement of litigation of $2.4 million ($0.34 per share). **p** Includes loss on abandonment of phenol facility of $4.4 million ($0.38 per share). **q** Includes net loss from shutdown and disposal of assets of $6.6 million ($0.50 per share). **r** Excludes extraordinary tax credit of $7.3 million ($0.57 per share). **s** From continuing operations; excludes provision for loss on disposal of discontinued operations of $2.5 million ($0.19 per share).

Money figures in thousands of dollars unless otherwise indicated

Year	Net sales	Net income	Total assets	Current ratio	Net plant and equipment	Capital expenditures	Net worth	NET INCOME			Dividends, $ per share	Dividend yield, % of price	Stock price range, $ per share	Price-earnings ratio
								% of sales	% of net worth	$ per share				
Stauffer Chemical Co.														
1981	$1,726,236	$150,093[a]	$2,013,863	2.4	$1,170,253	$238,555	$1,009,034	8.7%	14.9%	$3.41[a]	$1.29	5.5%	$\$27\frac{3}{4}-18\frac{3}{4}$	6.8
1980	1,695,219	121,743[b]	2,084,441	1.4	1,072,896	246,454	909,490	7.2	13.4	2.77[b]	1.175	6.0	$24\frac{3}{8}-14\frac{1}{2}$	7.0
1979	1,526,160	135,961	1,846,866	1.7	1,040,542	239,303	821,777	8.9	16.5	3.10	1.075	5.0	$25-17\frac{3}{4}$	6.9
1978	1,328,114	126,015	1,635,956	2.0	903,246	201,196	730,064	9.5	17.3	2.88	0.975	4.7	$24\frac{5}{8}-17$	7.2
Stepan Chemical Co.														
1981	$204,522	$6,545[c]	$176,068	1.5	$67,906	$12,083	$53,888	3.2%	12.1%	$1.74	$0.515	3.0%	$\$21\frac{7}{8}-12\frac{3}{8}$	9.8
1980	157,517	3,683[d]	137,688	1.5	64,338	9,204	50,498	2.5	7.3	0.98[d]	0.47	4.5	$12\frac{1}{4}-8\frac{1}{2}$	10.5
1979	144,981	4,794[e]	112,700	2.3	66,121	13,575	46,399	3.3	10.3	1.20[e]	0.415	4.2	$11\frac{3}{4}-8\frac{1}{4}$	7.8
1978	122,947	4,613	97,191	2.5	58,367	13,738	42,530	3.8	10.8	1.23	0.37	3.4	$13\frac{1}{2}-8\frac{3}{8}$	8.8
Union Carbide Corp.														
1981	$10,168,000	$649,000	$10,366,000	2.1	$5,794,000	$1,186,000	$5,206,000	6.4%	12.5%	$ 9.56	$3.30	6.1%	$\$62\frac{1}{8}-45\frac{1}{4}$	5.6
1980	9,994,000	673,000[f]	9,600,000	2.1	5,207,000	1,129,000	4,717,000	6.7	14.3	10.08[f]	3.10	7.1	$52\frac{1}{2}-35\frac{1}{4}$	4.4
1979	9,176,500	556,200[g]	8,710,000	2.1	4,458,300	831,300	3,949,900	6.1	14.1	8.47[g]	2.90	7.4	$44\frac{1}{2}-34$	4.6
1978	7,869,700	394,300[h]	7,776,000	2.0	4,118,900	687,800	3,548,300	5.0	11.1	6.09[h]	2.80	7.3	$43\frac{1}{4}-33\frac{5}{8}$	6.3
Williams Cos.														
1981	$1,976,336	$ 99,167[i]	$2,445,877	1.6	$1,497,797	$233,184	$1,027,245	5.0%	9.7%	$3.32[i]	$1.20	3.4%	$\$46\frac{5}{8}-23\frac{1}{2}$	10.6
1980	2,072,686	138,696	2,380,001	1.8	1,417,799	339,625	965,715	6.7	14.4	5.07	1.10	2.9	$49\frac{3}{8}-26\frac{3}{4}$	7.5
1979	1,850,013	69,450	2,005,511	1.7	1,190,526	112,995	737,949	3.8	9.4	2.55	1.00	4.2	$32\frac{1}{4}-15$	9.3
1978	1,497,008	29,534[j]	2,075,114	1.6	1,223,884	131,940	705,567	2.0	4.2	1.09[j]	1.00	5.3	$23\frac{5}{8}-14$	17.3
Witco Chemical Corp.														
1981	$1,291,878	$38,580	$707,181	1.7	$281,945	$55,479	$277,973	3.0%	13.9%	$4.14	$1.65	6.1%	$\$31\frac{1}{2}-22\frac{3}{4}$	6.6
1980	1,175,695	40,954	612,882	2.1	238,761	45,663	248,315	3.5	16.5	4.50	1.50	5.6	$33\frac{3}{4}-20\frac{1}{4}$	6.0
1979	966,758	42,782	551,891	1.9	192,902	40,890	222,686	4.4	19.2	4.83	1.30	5.1	$30\frac{1}{2}-20$	5.2
1978	751,733	33,495	405,042	1.9	166,475	31,991	189,844	4.5	17.6	3.86	1.11	5.3	$24\frac{7}{8}-16\frac{5}{8}$	5.4
PHARMACEUTICALS														
Abbott Laboratories														
1981	$2,342,524	$247,283	$2,355,613	1.1	$729,402	$200,600	$1,152,050	10.6%	21.5%	$2.01	$0.72	2.6%	$\$32\frac{1}{4}-23\frac{5}{8}$	13.9
1980	2,038,155	214,413	2,062,835	1.2	583,214	162,548	1,027,222	10.5	20.9	1.73	0.60	2.6	$28\frac{1}{2}-17$	13.2
1979	1,683,168	178,981[k]	1,729,296	1.3	466,970	109,636	896,028	10.6	20.0	1.48[k]	0.50	2.7	$21\frac{3}{4}-14\frac{3}{4}$	12.3
1978	1,445,017	148,626[l]	1,453,233	1.4	403,452	84,149	773,505	10.3	19.2	1.24[l]	0.39	2.4	$20-12\frac{1}{2}$	13.1
American Home Products Corp.														
1981	$4,131,237	$497,332	$2,517,541	3.0	$492,879	$99,852	$1,583,475	12.0%	31.4%	$3.18	$1.90	5.8%	$\$37\frac{1}{4}-28\frac{1}{8}$	10.3
1980	3,798,524	445,889	2,289,460	2.8	450,490	99,393	1,391,972	11.7	32.0	2.84	1.70	6.4	$31\frac{7}{8}-21\frac{3}{8}$	9.4
1979	3,401,301	396,039	2,007,977	3.0	408,899	87,809	1,239,315	11.6	32.0	2.51	1.50	5.6	$29\frac{1}{2}-24\frac{3}{8}$	10.7
1978	3,062,633	348,422	1,779,023	2.9	369,214	67,631	1,094,798	11.4	31.8	2.21	1.325	4.5	$32\frac{3}{4}-26\frac{1}{8}$	13.3
Baxter Travenol Laboratories														
1981	$1,503,890	$150,581	$1,590,743	2.6	$583,084	$ 87,101	$978,325	10.0%	15.4%	$2.15	$0.38	1.3%	$\$33\frac{3}{4}-24$	13.4
1980	1,374,384	128,400	1,412,638	2.8	560,690	118,645	852,606	9.3	15.1	1.86	0.32	1.4	$28\frac{3}{8}-17\frac{7}{8}$	12.4
1979	1,191,193	111,908[m]	1,290,928	2.3	500,976	103,654	723,510	9.4	15.5	1.14[m]	0.25	1.2	$24\frac{3}{4}-17\frac{3}{4}$	12.9
1978	1,004,196	91,683[n]	1,129,637	2.2	445,223	90,057	612,231	9.1	15.0	1.37[n]	0.20	1.0	$24\frac{7}{8}-16\frac{3}{8}$	15.1
Bristol-Myers Co.														
1981	$3,496,700	$305,800	$2,406,000	2.2	$581,800	$159,300	$1,482,000	8.7%	20.6%	$4.58	$1.78	3.4%	$\$58\frac{3}{4}-45\frac{3}{4}$	11.4
1980	3,158,300	270,600	2,125,500	2.3	484,900	131,600	1,296,200	8.6	20.9	4.08	1.56	3.8	$52-30\frac{1}{2}$	10.1
1979	2,752,777	231,545	1,837,648	2.4	407,528	95,022	1,117,002	8.4	20.7	3.50	1.385	4.0	$38\frac{1}{4}-31$	9.9
1978	2,450,429	203,048	1,619,015	2.3	358,515	81,922	981,624	8.3	20.7	3.08	1.19	3.5	$40\frac{3}{8}-28$	11.1
Eli Lilly & Co.														
1981	$2,773,205	$374,478	$2,902,262	1.9	$1,006,180	$253,735	$1,888,260	13.5%	19.8%	$4.93	$2.375	4.2%	$\$68\frac{3}{4}-45\frac{1}{4}$	11.6
1980	2,558,637	341,974	2,607,452	2.0	849,034	230,700	1,736,693	13.4	19.7	4.52	2.20	4.0	$65\frac{1}{2}-45\frac{3}{4}$	12.3
1979	2,205,764	329,531	2,179,132	2.4	672,610	172,678	1,570,439	14.9	21.0	4.52	1.95	3.5	$63\frac{7}{8}-47\frac{1}{8}$	12.3
1978	1,852,090	277,475	2,049,901	2.1	551,657	89,550	1,384,082	15.0	20.0	3.81	1.65	3.6	$54-36\frac{5}{8}$	11.9
Merck & Co.														
1981	$2,929,455	$398,265	$3,310,000	1.7	$1,395,567	$322,814	$2,001,460	13.6%	19.9%	$5.36	$2.60	2.9%	$\$103-76\frac{1}{4}$	16.7
1980	2,734,012	415,396	2,865,755	2.3	1,185,244	256,488	1,863,322	15.2	22.3	5.54	2.30	3.2	$86-58\frac{1}{4}$	13.0
1979	2,384,627	381,776	2,614,064	2.2	1,027,644	170,134	1,665,496	16.0	22.9	5.06	1.90	2.8	$74\frac{1}{4}-62\frac{1}{2}$	13.5
1978	1,981,440	307,534	2,251,348	2.4	924,179	155,853	1,455,135	15.5	21.1	4.07	1.70	2.9	$69\frac{1}{4}-47\frac{3}{8}$	14.3

a Excludes net loss on facility disposal and asset write-down of $169,000. **b** Excludes net gain on disposal of facilities of $14.8 million ($0.34 per share). **c** Includes loss on sale of flavor compounding business, before taxes, of $890,000. **d** Excludes net gain on sale of Polychem department of $1.7 million ($0.93 per share). **e** Excludes net gain on sale of fragrance business of $528,000 ($0.28 per share). **f** Excludes cumulative effect of change in accounting principle for the investment tax credit of $217 million ($3.28 per share). **g** Includes net charge on sales and disposals of assets of $21.1 million. **h** Includes net gain on sales of European ethylene derivatives business and other businesses of $54.4 million. **i** From continuing operations; excludes net income from discontinued operations of $10.4 million ($0.35 per share). **j** From continuing operations; excludes net loss from discontinued operations of $16.7 million ($0.62 per share). **k** Includes net gain on sale of animal health business of $1.8 million ($0.02 per share). **l** Includes net gain on sale of blood products business of $3.3 million ($0.03 per share). **m** Includes net gain on sale of assets of $450,000. **n** Includes net gain on sale of enzyme facilities of $700,000.

2 Finances of the U.S. Chemical Industry

Money figures in thousands of dollars unless otherwise indicated

Year	Net sales	Net income	Total assets	Current ratio	Net plant and equipment	Capital expenditures	Net worth	NET INCOME			Dividends, $ per share	Dividend yield, % of price	Stock price range, $ per share	Price-earnings ratio
								% of sales	% of net worth	$ per share				
Morton-Norwich Products														
1981[a]	$957,584	$53,010	$664,939	2.0	$279,132	$55,206	$350,630	5.5%	15.1%	$3.90	$1.49	4.6%	$38⅝-26⅛	8.3
1980[a]	846,601	47,730	590,077	2.1	250,911	52,094	316,902	5.6	15.1	3.52	1.40	5.1	34-21¼	7.8
1979[a]	731,984	46,088	566,039	2.6	223,224	48,593	297,777	6.3	15.5	3.40	1.26	4.2	34⅛-25¾	8.8
1978[a]	656,733	36,938	504,465	3.2	195,337	29,139	272,027	5.6	13.6	2.85	1.11	3.8	34⅞-23½	10.2
Pfizer														
1981	$3,249,700	$273,700[b]	$3,544,200	1.9	$998,200	$287,100	$1,594,700	8.4%	17.2%	$3.63[b]	$1.60	3.4%	$54⅞-40	13.1
1980	3,029,300	254,800	3,247,300	1.9	825,000	163,600	1,456,500	8.4	17.5	3.48	1.44	3.4	53¾-32	12.3
1979	2,746,025	237,869	2,945,280	2.0	759,269	133,300	1,310,074	8.7	18.2	3.26	1.32	3.7	41¾-29	10.9
1978	2,362,133	206,256	2,643,611	2.0	709,957	110,100	1,149,537	8.7	17.9	2.93	1.17	3.6	39-25½	11.0
Richardson-Vicks														
1981[a]	$1,088,100	$83,200[c]	$672,200	1.7	$208,600	$49,300	$365,300	7.6%	22.8%	$3.47[d]	$1.32	4.7%	$34¾-21¾	8.1
1980[a,d]	1,211,651	84,209	829,551	2.0	242,568	52,630	427,938	6.9	19.7	3.56	1.20	4.3	38⅛-17½	7.8
1979[a,d]	1,090,546	62,956	718,229	2.1	209,251	47,545	376,852	5.8	16.7	2.66	1.06	4.5	27-19¾	8.8
1978[a,d]	944,961	66,179	631,801	2.0	192,413	29,681	333,005	7.0	19.9	2.80	0.90	3.5	31-19⅞	9.1
A. H. Robins Co.														
1981	$450,854	$44,228[e]	$385,483	3.0	$96,457	$28,103	$251,742	9.8%	17.6%	$1.77[e]	$0.44	3.8%	$14¾-8½	6.6
1980	432,328	25,470[f]	337,318	2.9	80,511	30,273	227,142	5.9	11.2	1.01[f]	0.42	4.4	12½-6⅝	9.5
1979	386,425	44,746[g]	329,072	2.8	59,994	16,687	222,148	11.6	20.1	1.71[g]	0.40	4.0	12-8¼	5.9
1978	357,070	29,916	273,895	3.6	55,350	12,643	188,097	8.4	15.9	1.15	0.34	3.2	12⅞-8⅝	9.3
Schering-Plough Corp.														
1981	$1,808,800	$179,300	$2,214,500	1.9	$654,600	$170,300	$1,254,200	9.9%	14.3%	$3.31	$1.66	4.9%	$42½-24⅞	10.2
1980	1,740,400	239,300	1,925,800	1.7	524,800	130,900	1,193,800	13.7	20.0	4.45	1.56	4.2	45⅝-29⅛	8.4
1979	1,434,022	222,267	1,534,245	2.0	415,401	68,316	1,037,354	15.5	21.4	4.12	1.39	4.4	35¼-27½	7.6
1978	1,082,493	193,629	1,183,919	2.7	319,551	51,336	848,558	17.9	22.8	3.62	1.21	3.8	38-26¼	8.9
G. D. Searle & Co.														
1981	$ 942,300	$130,900[h]	$1,050,400	2.3	$279,300	$87,600	$533,600	13.9%	24.5%	$2.52[h]	$0.52	1.7%	$35½-25⅛	12.0
1980	1,081,558	94,341[i]	1,089,920	1.4	249,695	66,961	508,844	8.7	18.5	1.78[i]	0.52	2.3	27⅝-17¼	12.6
1979	898,369	89,004[j]	1,099,383	1.9	212,972	49,253	456,358	9.9	19.5	1.68[j]	0.52	3.3	20-11½	9.4
1978	848,380	72,187	964,962	3.1	179,710	40,413	414,983	8.5	17.4	1.37	0.52	3.8	16⅝-10⅝	9.9
SmithKline Beckman Corp.														
1981	$1,985,341	$370,000	$1,796,105	2.3	$580,920	$200,816	$1,138,457	18.6%	32.5%	$5.55	[illegible]	2.8%	$88⅜-63⅞	13.7
1980	1,771,938	307,994	1,490,914	2.4	421,788	132,806	923,723	17.4	33.3	4.65	1.725	2.8	80⅝-43½	13.3
1979	1,351,145	233,837	1,150,260	2.3	289,847	93,494	667,468	17.3	35.0	3.85	1.32	2.6	63¼-38½	13.2
1978	1,112,039	164,075	894,224	2.4	224,929	75,579	503,770	14.8	32.6	2.72	0.78	2.1	51¼-23⅛	13.6
Squibb Corp.														
1981	$1,523,911	$ 41,098[k]	$1,900,424	2.1	$479,720	$69,851	$979,689	2.7%	4.2%	$0.83[k]	$1.215	3.8%	$37⅝-26⅝	38.7
1980	1,675,709	123,079[l]	1,858,270	2.3	600,895	89,032	964,504	7.3	12.8	2.56[l]	1.155	3.6	39¼-24⅜	12.4
1979	1,782,894	123,722	1,747,688	2.2	630,047	109,970	881,875	6.9	14.0	2.71	1.095	3.3	39¼-27	12.2
1978	1,515,882	117,255	1,541,165	2.2	559,090	108,046	793,219	7.7	14.8	2.60	1.035	3.5	37⅜-21⅜	11.3
Sterling Drug														
1981	$1,792,925	$130,303	$1,226,410	2.5	$334,960	$77,016	$787,542	7.3%	16.5%	$2.15	$0.98	4.3%	$26⅛-19	10.5
1980	1,701,433	123,337	1,214,231	2.4	318,109	70,051	752,640	7.2	16.4	2.04	0.90	4.2	26⅞-16	10.5
1979	1,500,602	111,594	1,105,581	2.3	280,594	58,186	680,649	7.4	16.4	1.85	0.82	4.5	21⅜-15¼	9.9
1978	1,314,630	94,675	959,470	2.5	255,603	36,933	618,767	7.2	15.3	1.57	0.75	4.7	19¼-12¾	10.2
Upjohn Co.														
1981	$1,898,334	$181,764	$1,940,485	2.0	$614,481	$139,211	$965,267	9.6%	18.8%	$6.04	$2.07	3.6%	$ 69-45⅝	9.5
1980	1,760,576	170,375	1,669,621	1.9	544,322	109,800	865,753	9.7	19.7	5.71	1.93	3.5	68-41½	9.6
1979	1,508,025	149,478	1,403,734	2.1	476,367	77,498	743,659	9.9	20.1	5.03	1.62	3.6	50½-40	9.0
1978	1,328,551	129,405	1,207,625	2.3	437,803	44,681	639,753	9.7	20.2	4.36	1.37	3.1	56-32⅛	10.1
Warner-Lambert Co.														
1981	$3,379,952	$ 9,222[m]	$2,662,418	1.7	$869,753	$165,833	$1,084,796	0.3%	0.9%	$0.12[m]	$1.34	6.4%	$ 25-17⅛	175.5
1980	3,479,207	192,716[n]	2,638,077	2.1	827,131	138,688	1,171,477	5.5	16.5	2.41[n]	1.32	6.6	23¼-17	8.4
1979	3,217,208	123,346[o]	2,542,167	1.9	775,253	155,473	1,067,151	3.8	11.6	1.55[o]	1.29	5.8	26½-17⅜	14.3
1978	2,878,496	207,947	2,318,839	2.0	715,880	133,748	1,026,713	7.2	20.3	2.61	1.175	4.2	32½-22⅞	10.6

a Fiscal year ends June 30. b From continuing operations; excludes net loss from discontinued diagnostic imaging operations and provision for loss on disposal of discontinued operations of $52.4 million ($0.68 per share). c From continuing operations; excludes net loss from discontinued ethical pharmaceutical businesses of $3.9 million ($0.16 per share). d Data for Richardson-Merrell prior to sale (in March 1981) of ethical pharmaceutical businesses to Dow Chemical Co. e Includes income, before taxes, from litigation settlement of $3.4 million. f Includes income, before taxes, from litigation settlement of $3.6 million and provision for net losses on disposition of businesses of $4.7 million ($0.19 per share). g Includes income, before taxes, from settlement of antitrust litigation of $28.9 million. h From continuing operations; excludes net loss from operations and disposition of discontinued businesses of $26.0 million ($0.50 per share) and debit for cumulative effect of changes in accounting principles of $6.2 million ($0.12 per share). i From continuing operations; excludes reserve for loss from sale of assets of diagnostic business of $9.0 million ($0.17 per share) and extraordinary tax credit of $13.0 million ($0.24 per share). j From continuing operations; excludes net loss from operations of divested diagnostic business of $1.1 million ($0.02 per share). k From continuing operations; excludes net gain on sale of confectionery products business of $58.1 million ($1.16 per share), net income from that business of $12.2 million ($0.24 per share), and extraordinary charge relating to takeover of operations in Iran of $6.5 million ($0.13 per share). l From continuing operations; excludes net income of divested food services and related operations of $4.3 million ($0.09 per share). m Includes net nonrecurring charge of $134 million ($1.68 per share). n Includes net nonrecurring charge of $3 million ($0.03 per share). o Includes net nonrecurring charges and tax settlement of $64 million ($0.80 per share).

Productivity makes slim gain as capacity use remains low

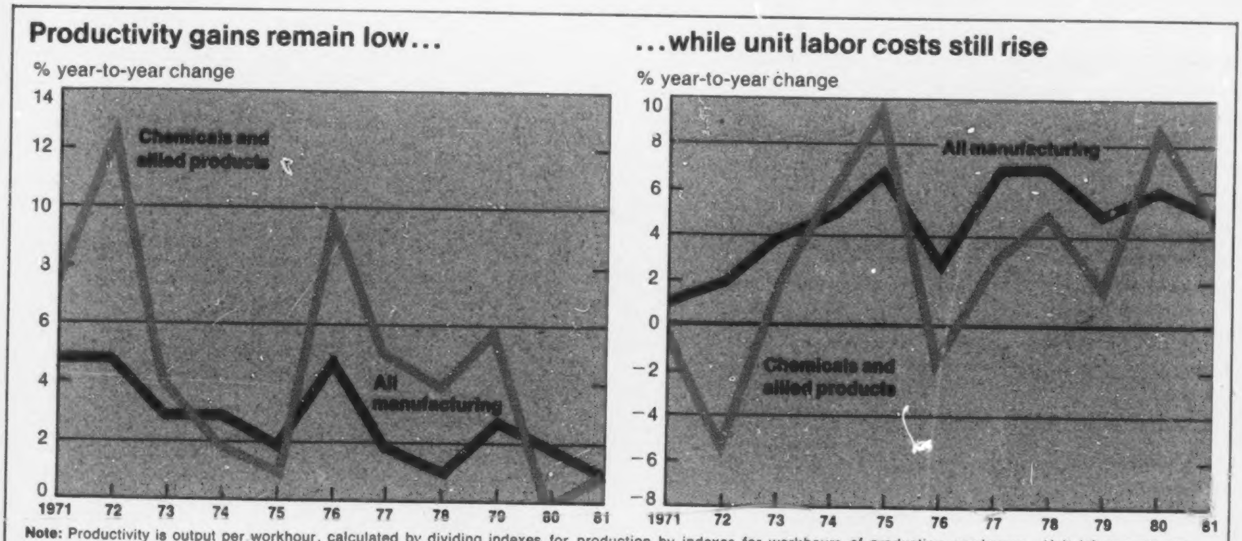
The U.S. chemical industry's productivity problems of the past decade continued in 1981, leading to another sizable increase in unit labor costs. A big contributor was low plant operating rates, which have become even worse in 1982.

In 1981, the industry eked out a 1% increase in productivity (output per workhour) after no gain at all in 1980. Manufacturing as a whole did no better in 1981 and slightly outpaced chemicals in 1980. By contrast, average annual productivity gains over the past decade were 5% in chemicals and 3% in all manufacturing.

Since wages still went up briskly in 1981, unit labor costs climbed again, although not to the very high levels of 1980. The 1981 increase, 5% for both chemicals and all manufacturing, was about in line with decade averages of 4% in chemicals and 5% in all manufacturing.

At the same time, output at U.S. plants of the leading chemicals measured by C&EN picked up to 74% of nameplate capacity in 1981 from 68% in third-quarter 1980. However, since then, plant use has plummeted to an even lower 62% in the first quarter of 1982.

Government measures of plant capacity use parallel C&EN's, although at slightly higher levels. For chemicals and allied products, year-end capacity use was 70% in 1981, cut from 78% in 1980 and 83% in the last good year, 1979. These rates are close to averages for all manufacturing, which was running at 72% of capacity as 1981 closed.



Productivity gains remain low... **...while unit labor costs still rise**

Note: Productivity is output per workhour, calculated by dividing indexes for production by indexes for workhours of production employees. Unit labor costs are labor costs per unit of output, calculated by dividing indexes for wages by indexes for output per workhour. **Sources:** Department of Labor, Federal Reserve Board, C&EN calculations

PRODUCTIVITY: Chemical industry rebounds slightly in 1981 after drop in 1980

Indexes, 1967 = 100	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971
CHEMICALS AND ALLIED PRODUCTS											
Production	215.6	207.1	211.8	197.4	185.7	170.9	147.2	159.4	154.4	143.6	125.9
Workhours	108.8	105.4	107.7	106.8	104.5	101.4	96.5	105.1	103.7	100.3	99.2
Productivity	198.2	196.5	196.7	184.8	177.7	168.5	152.5	151.7	148.9	143.2	126.9
Hourly production wages	282.9	267.4	245.2	226.5	207.4	190.7	173.9	157.4	145.5	137.4	128.0
Unit labor costs	142.7	136.5	124.7	122.6	116.7	113.2	114.0	103.8	97.7	95.9	100.9
ALL MANUFACTURING											
Production	150.4	146.7	153.6	146.8	138.4	130.3	116.3	129.4	129.8	118.9	108.2
Workhours	98.3	96.4	103.4	101.8	97.3	93.4	87.8	100.0	103.1	97.3	93.1
Productivity	153.0	152.2	148.6	144.2	142.2	139.5	132.5	129.2	125.9	122.2	116.2
Hourly production wages	273.4	257.8	237.6	218.8	201.4	185.1	171.3	156.7	145.0	135.5	126.6
Unit labor costs	178.7	169.4	159.9	151.7	141.6	132.7	129.3	121.1	115.2	110.9	109.0

Sources: Department of Labor, Federal Reserve Board, C&EN calculations

3 Performance by the U.S. Chemical Industry

OPERATING RATES: Use of chemical plant capacity is down sharply

Billions of lb per year unless otherwise noted[a]	1ST-QTR 1982		3RD-QTR 1981		1ST-QTR 1981		3RD-QTR 1980		1ST-QTR 1980		3RD-QTR 1979	
	Capacity[b]	Use	Capacity[b]	Use	Capacity[b]	Use	Capacity[b]	Use	Capacity[b]	Use	Capacity[b]	Use
ORGANIC CHEMICALS												
Benzene (bg)	2.7	39%	2.7	67%	2.5	68%	2.4	64%	2.6	70%	2.3	77%
Butadiene[c]	4.6	42	4.6	67	4.6	61	4.0	65	4.7	75	4.0	90
Cyclohexane	3.1	33	3.4	59	3.4	62	3.4	52	3.2	85	3.2	78
DMT-TPA[d]	7.3	58	7.3	71	7.3	71	7.3	59	7.3	75	7.3	68
Ethylene	39.7	56	41.0	65	40.0	68	40.0	63	37.0	84	36.5	89
Formaldehyde, 37% solution	8.9	51	8.9	65	8.9	66	8.6	59	8.5	72	8.5	79
Methanol (bg)	1.5	72	1.4	83	1.4	90	1.4	80	1.4	83	1.4	85
Phenol	4.0	56	4.0	67	3.6	69	3.7	65	3.6	81	3.4	82
Propylene, chemical	23.5	43	23.5	59	23.5	58	23.8	48	20.5	79	20.5	72
Styrene	8.7	79	8.9	74	8.9	82	8.9	55	9.3	87	8.4	89
Urea	8.1	63	8.0	90	8.0	88	8.0	91	7.7	86	7.5	87
Vinyl acetate	2.4	72	2.4	79	2.5	78	2.5	68	2.5	79	2.4	83
Vinyl chloride	9.6	50	9.7	70	9.2	65	8.2	63	8.7	89	8.4	99
***p*-Xylene**	4.9	61	5.6	64	5.6	75	5.6	68	5.3	70	5.7	79
INORGANIC CHEMICALS												
Ammonia (mt)	20.8	80	24.0	80	24.0	83	24.0	75	20.4	95	20.4	91
Carbon black	3.4	75	3.4	82	3.7	76	3.7	61	3.8	68	4.3	73
Carbon dioxide (ttd)	17.7	63	16.4	71	15.6	69	15.6	68	14.1	69	12.5	52
Caustic soda (mt)	15.6	59	15.5	75	15.6	73	15.3	68	15.5	79	15.1	85
Chlorine (mt)	14.7	62	14.8	78	14.7	73	14.6	69	14.4	84	14.4	88
Nitrogen **Oxygen** } total, liquid (ttd)	37.6	64	36.0	66	34.8	63	33.6	69	32.4	68	31.2	67
Phosphoric acid, (P_2O_5) (mt)	12.4	62	11.5	91	11.7	94	11.7	87	11.0	94	9.8	94
Phosphorus (mt)	0.55	66	0.55	78	0.55	78	0.55	70	0.55	83	0.55	78
Soda ash (mt)	10.4	76	10.0	83	10.0	82	9.7	79	9.7	85	9.1	92
Sulfuric acid (mt)	59.4	54	58.5	74	58.3	74	58.0	76	57.5	76	56.0	81
Titanium dioxide (mt)	1.0	53	1.0	82	1.0	77	1.0	66	1.0	75	0.88	88
AVERAGE		**62%**		**74%**		**74%**		**68%**		**80%**		**82%**

a bg= billions of gallons, mt = millions of tons, ttd = thousands of tons per day. **b** Nameplate capacity. **c** Based on extraction capacity of steam-cracking olefins plants, dehydrogenation and extraction capacity of dehydrogenation plants, and other butadiene recovery capacity. **d** Dimethyl terephthalate-purified terephthalic acid, not including acid converted to dimethyl terephthalate.
Sources: Industry sources, C&EN estimates

Surplus capacity ballooned in chemical process industries last year

	Operating rate, % of nameplate capacity, as of December										
	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971
Chemicals	70%	78%	83%	83%	76%	78%	78%	81%	88%	85%	81%
Paper	83	89	91	89	87	85	85	84	93	91	87
Petroleum	73	80	86	91	91	93	91	90	95	94	93
Rubber	66	70	70	84	81	85	81	77	84	89	86
Textiles	75	80	82	85	87	84	85	69	89	91	86
All manufacturing	72	78	81	84	82	81	79	78	85	85	80

Source: Department of Commerce

ENERGY USE BY CHEMICAL INDUSTRY: Gas, oil, steam drop; electricity rises

Energy source[a]	1981		1980		1979		1978		1972		Change 1972–81	
	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	%
Natural gas	1264	40.2%	1293	39.7%	1371	38.6%	1237	37.1%	1671	47.2%	−407	−24.4%
Purchased electricity[b]	928	29.5	943	29.0	998	28.1	876	26.3	771	21.8	157	20.4
Petroleum-based fuels	542	17.2	621	19.1	762	21.5	800	24.0	644	18.2	−102	−15.8
Light hydrocarbons[c]	351	11.1	380	11.7	433	12.2	370	11.1	363	10.3	−12	−3.3
Residual fuels	104	3.3	141	4.3	217	6.1	269	8.1	179	5.0	−75	−41.9
Distillate fuels	18	0.6	23	0.7	37	1.0	64	1.9	33	0.9	−15	−45.5
Other fuel[d]	70	2.2	77	2.4	75	2.1	98	2.9	69	1.9	1	1.4
Coal and coke	314	10.0	301	9.3	305	8.6	305	9.1	328	9.3	−14	−4.3
Purchased steam	98	3.1	95	2.9	115	3.2	117	3.5	127	3.6	−29	−22.8
TOTAL	3147	100.0%	3255	100.0%	3550	100.0%	3335	100.0%	3542	100.1%	−395	−11.2%

a For energy and process use only, excluding energy equivalent of feedstock. b Electricity is calculated as fuel value of 10,000 Btu to generate 1 kWh instead of using standard conversion factor of 3412 Btu per kWh. c Includes propane, liquefied petroleum gas, and other gases. d Includes petroleum coke, gasoline, and other liquids and solids. **Note:** Data from companies accounting for about 90% of U.S. capacity for basic industrial chemicals. **Source:** Chemical Manufacturers Association

ENERGY USE BY FERTILIZER INDUSTRY: Gas's big share gets even bigger

Energy source[a]	1981		1980		1979[b]		1972		Change 1972–81	
	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	%
Natural gas	200.6	81.2%	205.0	79.3%	206.1	77.9%	161.5	79.2%	39.1	24.2%
Purchased electricity[c]	43.7	17.7	46.9	18.2	49.2	18.6	35.5	17.4	8.2	23.1
Petroleum-based fuels	1.8	0.7	5.6	2.2	8.6	3.3	6.3	3.1	−4.5	−71.4
Light hydrocarbons[d]	0	0	0.4	0.2	0.4	0.1	0.1	0	−0.1	−100.0
Residual fuels	1.0	0.4	4.5	1.7	5.4	2.0	3.8	1.9	−2.8	−73.7
Distillate fuels	0.7	0.3	0.7	0.3	2.7	1.0	2.2	1.1	−1.5	−68.2
Other fuel[e]	0.1	0.1	0.2	0.1	0.2	0.1	0.1	0.1	0	0
Coal and coke	0.5	0.2	0.6	0.2	0.5	0.2	0.5	0.2	0	0
Purchased steam	0.4	0.1	0.2	0.1	0.2	0.1	0.1	0	0.3	300.0
TOTAL	246.9	99.9%	258.5	100.0%	264.6	100.1%	203.8	99.9%	43.1	21.1%

a For energy and process use only, excluding energy equivalent of feedstock. b Figures for 1979 include 18 companies (with total energy consumption of 209 trillion Btu) that use 1972 as a reference base and four companies (with total energy consumption of 56 trillion Btu) that use 1978 as a reference base instead; 1979 figures thus are not completely comparable to other years. c Electricity is calculated as fuel value of 10,000 Btu to generate 1 kWh instead of using standard conversion factor of 3412 Btu per kWh. d Includes propane and liquefied petroleum gas. e Includes gasoline, diesel oil, kerosene, and other fuels. **Note:** Data from companies accounting for more than 70% of U.S. fertilizer capacity. **Source:** Fertilizer Institute

ENERGY USE BY PETROLEUM INDUSTRY: Electricity's share is small but growing

Energy source[a]	1981		1980		1979		1978		1972		Change 1972–81	
	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	% of total	Trillion Btu	%
Natural gas	685	24.7%	734	25.1%	758	25.0%	676	22.6%	1033	33.6%	−348	−33.7%
Purchased electricity[b]	250	9.0	253	8.6	242	8.0	231	7.7	201	6.5	49	24.4
Petroleum-based fuels	1809	65.1	1903	65.1	1989	65.7	2050	68.4	1796	58.5	13	0.7
Light hydrocarbons[c]	1193	43.0	1243	42.5	1291	42.7	1287	42.9	1067	34.8	126	11.8
Residual fuels	177	6.4	215	7.3	234	7.7	306	10.2	258	8.4	−81	−31.4
Petroleum coke	428	15.4	425	14.5	431	14.3	422	14.1	442	14.4	−14	−3.2
Other fuel[d]	11	0.4	19	0.7	33	1.1	35	1.2	29	0.9	−18	−62.1
Coal and coke	5	0.2	4	0.1	5	0.2	3	0.1	5	0.2	0	0
Purchased steam	28	1.0	31	1.1	32	1.1	38	1.3	37	1.2	−9	−24.3
TOTAL	2777	100.0%	2925	100.0%	3026	100.0%	2998	100.1%	3071	100.0%	−294	−9.6%

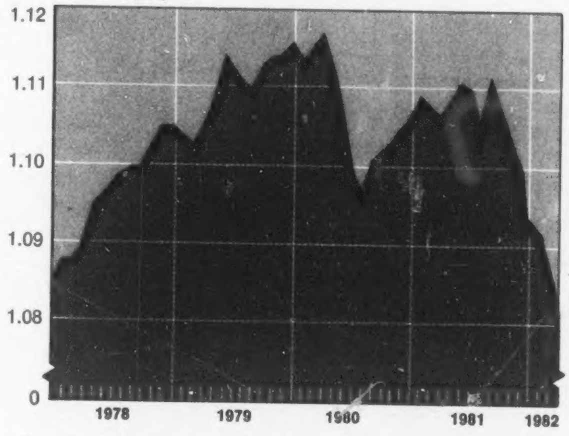
a For energy and process use only, excluding energy equivalent of feedstock. b Electricity is calculated as fuel value of 10,000 Btu to generate 1 kWh instead of using standard conversion factor of 3412 Btu per kWh. c Includes propane, liquefied petroleum gas, and refinery gas. d Includes distillate fuels, gasoline, and other liquids. **Note:** Data from companies accounting for more than 90% of U.S. petroleum refining capacity. **Source:** American Petroleum Institute

Chemical jobs recover then turn down again

The U.S. chemical industry has not been hit by the massive job layoffs that have plagued many other segments of industry, such as automobiles, steel, farm machinery, and construction, during the past 12 months. But employment clearly has been trending downward in the industry since the end of last summer, when the number of workers making chemicals peaked at a level several thousand lower than that reached before the 1980 recession.

Chemical employment has slumped about 30,000 (3%) since last summer, to a total less than that during the bottom of the 1980 recession and, in fact, lower than at any time since late 1977. However, layoffs have not been so severe as during the 1975 recession, when employment declined close to 70,000 over a 10-month period. As in the past, most of the layoffs have been among production or other nonsupervisory workers, for whom employment is at the lowest level since 1976.

Months of declining employment bring jobs in chemical industry to four-year low



a Seasonally adjusted employment in U.S. chemicals and allied products industry. **Source:** Department of Labor

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INDUSTRIAL EMPLOYMENT: No change last year in the chemical industry

	All employees[a] (thousands)				Production workers[a] (thousands)				Workweek[a,b] (hours)			
	1981	1980	1979	1971	1981	1980	1979	1971	1981	1980	1979	1971
All manufacturing	20,261	20,300	21,040	18,623	14,083	14,223	15,068	13,544	39.8	39.7	40.2	39.9
Chemicals and allied products	1,107	1,107	1,109	1,011	626	626	633	588	41.6	41.5	41.9	41.6
Industrial inorganic chemicals	163	162	162	na	89	88	88	na	41.5	41.5	42.1	na
Plastics materials and synthetics	200	206	212	226	132	137	144	143	42.0	41.4	42.1	42.1
Drugs	201	197	192	156	100	97	96	78	41.1	41.0	41.1	40.6
Soap, cleaners, and toilet goods	139	139	140	122	87	84	84	69	40.4	40.4	40.5	40.8
Paints and allied products	64	65	69	68	32	33	36	37	40.4	40.3	41.2	40.7
Industrial organic chemicals	171	171	171	na	86	87	89	na	42.8	42.8	43.4	na
Agricultural chemicals	73	73	70	na	46	46	45	na	43.0	43.4	42.9	na
Miscellaneous chemical products	96	94	93	na	55	53	52	na	41.3	41.0	41.5	na
Petroleum and coal products	211	197	210	194	132	124	137	124	43.2	41.8	43.8	42.8
Rubber and miscellaneous plastics products	744	731	82	580	574	562	612	450	40.4	40.1	40.5	40.3

a Domestic employment. b Workweek of production or nonsupervisory workers. **na** = not available. **Source:** Department of Labor

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EMPLOYMENT OF SCIENTISTS, ENGINEERS: Edges up to a new high in chemicals

Thousands[a]	1981[b]	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971
Total, all industry	470.2	446.6	423.2	403.7	382.8	364.4	363.3	360.0	357.7	350.2	367.0
Chemicals and allied products	52.8	50.0	49.1	47.9	46.4	44.4	45.2	41.8	40.9	41.0	42.7
Industrial chemicals	22.1	21.3	21.6	21.5	20.6	20.1	21.1	19.1	19.1	19.1	21.8
Drugs and medicines	21.1	20.0	19.7	18.9	17.8	16.6	15.6	14.0	13.0	13.1	12.3
Other chemicals	9.6	8.7	7.8	7.4	8.0	7.8	8.5	8.7	8.8	8.8	8.6
Petroleum refining	13.4	11.0	10.3	10.0	8.9	8.6	8.4	8.2	8.2	8.3	9.2
Rubber products	na	na	8.1	7.9	9.1	8.6	8.4	7.7	7.5	6.7	6.7

a Full-time-equivalent number of R&D scientists and engineers in industry, as of January of each year. b Preliminary. **na** = not available. **Source:** National Science Foundation

4 Employment in the U.S. Chemical Industry

CHEMICAL EMPLOYMENT: Little change in totals during past two years

Thousands	Worldwide employment									
	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972
Air Products	16.2	15.8	14.6	14.3	13.7	13.4	13.0	13.0	10.3	9.0
Akzona	15.5	15.9	15.4	15.3	15.6	15.6	15.8	19.5	19.6	17.7
Allied	58.2	46.3	49.0	32.0	32.8	33.4	33.4	32.2	33.5	32.7
American Cyanamid	41.8	42.6	44.2	44.0	43.8	39.4	37.8	38.0	39.5	41.4
Celanese	35.9	36.5	33.3	33.2	32.1	31.9	37.0	38.8	37.4	36.2
Crompton & Knowles	2.5	2.8	3.0	3.2	3.1	3.0	2.2	2.4	2.5	2.6
Dow Chemical	63.8	56.8	55.9	53.5	53.2	53.0	53.0	53.3	49.8	48.8
Ethyl	14.5	15.0	16.0	16.5	16.0	16.0	17.0	18.0	14.0	14.0
FMC	38.9	39.0	41.0	40.4	37.9	33.2	33.2	34.1	31.7	28.9
Freeport-McMoRan	5.2	2.7	3.9	3.5	3.7	3.8	3.5	3.3	2.9	2.3
H. B. Fuller	3.3	3.4	3.4	3.3	3.0	2.8	2.6	2.3	2.1	1.8
W. R. Grace	88.8	91.7	82.1	68.5	68.7	63.8	65.3	79.1	75.7	73.9
Hercules	22.8	22.9	24.4	24.5	24.0	24.0	23.5	25.3	24.1	22.4
International Flavors	3.6	3.6	3.6	3.5	3.3	3.1	2.9	3.1	2.8	2.7
International Minerals	10.6	10.6	10.3	9.9	9.9	9.7	10.5	6.6	6.2	6.2
Lubrizol	4.2	4.2	3.9	3.8	3.6	3.6	3.6	3.5	3.3	3.0
Monsanto	57.4	61.8	63.9	62.9	61.5	61.9	59.2	60.9	58.3	57.9
Nalco Chemical	4.7	4.4	4.1	4.1	4.2	3.8	3.5	3.4	3.2	2.9
Olin	20.3	21.0	21.7	22.7	22.4	22.0	23.0	23.0	24.0	32.0
Pennwalt	10.7	12.8	13.3	14.0	13.9	13.9	14.3	14.8	13.9	12.8
Reichhold Chemicals	5.6	5.6	6.4	6.5	6.5	5.8	4.3	4.1	4.3	3.4
Rohm & Haas	13.5	13.2	13.3	13.1	13.0	13.3	13.8	14.2	13.5	13.1
Stauffer Chemical	12.2	13.4	13.8	13.1	13.0	13.0	13.1	12.5	12.0	11.3
Stepan Chemical	0.9	0.8	0.9	0.8	0.8	0.7	0.7	0.8	0.7	0.6
Union Carbide	110.3	116.1	115.8	113.4	113.7	113.1	106.5	109.6	109.4	98.1
TOTAL EMPLOYEES	**661.4**	**658.9**	**659.2**	**624.1**	**613.4**	**597.6**	**592.9**	**615.8**	**594.8**	**583.5**
ANNUAL CHANGE	**0.4%**	**0.3%**	**5.3%**	**1.7%**	**2.6%**	**0.8%**	**−3.7%**	**3.5%**	**1.9%**	**2.0%**
SALES PER EMPLOYEE ($ thousands)	**$109.7**	**$103.5**	**$93.7**	**$89.2**	**$73.6**	**$68.5**	**$52.0**	**$57.3**	**$44.4**	**$34.5**

Note: Data for years prior to 1980 are not restated for acquisitions and similar adjustments.

WAGES: Better than average throughout the chemical industry

	Hourly earnings[a]				Weekly earnings[a]			
	1981	1980	1979	1971	1981	1980	1979	1971
All manufacturing	$ 7.98	$ 7.27	$6.70	$3.57	$317.60	$288.62	$269.34	$142.44
Chemicals and allied products	9.12	8.30	7.60	3.97	379.39	344.45	318.44	165.15
Industrial inorganic chemicals	10.17	9.08	8.26	na	422.06	376.82	347.75	na
Plastics materials and synthetics	9.03	8.21	7.48	3.84	379.26	339.89	314.91	161.66
Drugs	8.32	7.70	6.93	3.81	341.95	315.70	284.82	154.69
Soap, cleaners, and toilet goods	8.33	7.65	7.18	3.90	336.53	309.06	290.79	159.12
Paints and allied products	8.06	7.40	6.80	3.68	325.62	298.22	280.16	149.78
Industrial organic chemicals	10.72	9.67	9.02	na	458.82	413.88	391.47	na
Agricultural chemicals	8.89	8.12	7.26	na	382.27	352.41	311.45	na
Miscellaneous chemical products	8.47	7.76	7.06	na	349.81	318.16	292.99	na
Petroleum and coal products	11.37	10.09	9.36	4.57	491.18	421.76	409.97	195.60
Rubber and miscellaneous plastics products	7.25	6.56	5.97	3.39	292.90	263.06	241.79	136.62

[a] For production and nonsupervisory workers in domestic employment. **na** = not available. **Source:** Department of Labor

U.S. chemical trade surplus begins to narrow

World trade in chemicals declined last year to an estimated $124 billion from 1980's $139 billion.

That in itself may not be significant. But it has happened only once before in the past 20 years. That was in 1975, when the world's industrialized economies were suffering the shocks of the first oil crisis.

Last year, the economies of the major industrialized countries were again far from healthy. As a result, demand for chemical imports was down. Some countries made a conscious effort to shave imports in order to save jobs and prevent already-high trade deficits from becoming higher.

Under these circumstances, it was perhaps inevitable that world chemical trade would decline. When the worldwide economic situation improves, chemical trade no doubt will accelerate again.

What happened to U.S. chemical trade last year, however, certainly is significant. Chemical exports increased, but only 2.2% to $21 billion. That's a far cry from the 20% and 37% gains of the previous two years.

Meanwhile, U.S. chemical imports rose almost 10% to $9.4 billion, which lowered the chemical industry's cherished trade surplus from $12.1 billion to $11.7 billion. That is the first decline since 1972, and chemical industry trade experts fear that it may be a harbinger of things to come.

True, U.S. chemical exports suffered last year from weak international demand and a strong dollar, which made prices of U.S. products less competitive abroad. But trade experts see a more fundamental reason for last year's slow growth in chemical exports. It took place right after the government removed price controls on crude oil. That, they reason, erased some of the advantages in feedstock prices that U.S. producers enjoyed. If and when controls are removed from natural gas, the U.S. feedstock advantage will disappear entirely.

Meanwhile, plants now going up in countries rich in hydrocarbons figure to add a new dimension of competition to international chemical trade, starting as early as 1985. As a result, some experts believe that huge U.S. chemical trade surpluses soon may become a thing of the past.

U.S. TOTAL TRADE BALANCE:

Deficit widened by $3 billion last year

$ Millions	1981	1980	1979	1971
Exports[a]	$233,677	$220,626	$181,639	$43,549
Imports[b]	260,982	244,871	206,327	45,563
Trade balance	−27,305	−24,245	−24,688	−2,014

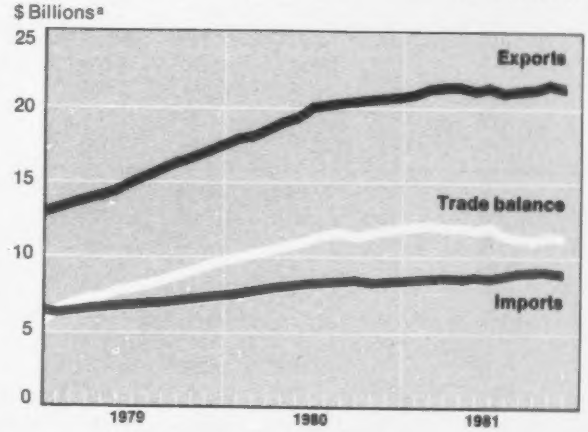
U.S. CHEMICAL TRADE BALANCE:

Surplus down in 1981 for first time in years

$ Millions	1981	1980	1979	1970
Chemical exports[c]	$21,187	$20,740	$17,306	$3,837
Chemical imports[b]	9,446	8,594	7,485	1,612
Chemical trade balance	11,741	12,146	9,821	2,225

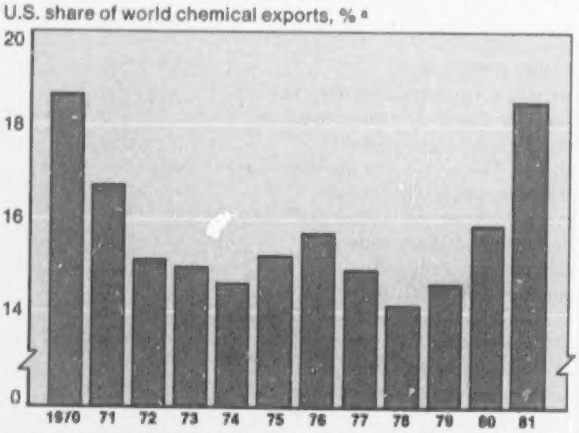
a Exports of domestic and foreign merchandise, excluding Department of Defense and Grant-Aid shipments; FAS (free along ship) value. b General imports; starting with 1974 reported as FAS value, prior to 1974 reported as foreign value, which is within 1% of FAS value. c Exports of domestic merchandise, including Department of Defense and Grant-Aid shipments. **Source:** Department of Commerce

U.S. chemical trade balance narrows a bit...



a Running 12-month values for U.S. chemical exports, imports, and trade balance. **Source:** Department of Commerce

...but U.S. share of world market is higher



a U.S. exports as a percentage of world chemical exports less U.S. imports. **Source:** C&EN estimates based on Department of Commerce and United Nations data

WORLD TRADE: U.S. tops West Germany

$ Millions	1981	1980	1979	1978
CHEMICAL EXPORTS				
World	$124,000[a]	$139,100[a]	$125,684	$24,408
U.S.	21,187	20,740	17,306	3,837
Canada	4,012	3,519	2,897	593
EC, nine countries[b]	64,002	76,348	69,225	12,929
Belgium-Luxembourg	5,870	7,422	6,644	1,179
France	10,241	13,249	11,646	1,960
Italy	4,727	5,505	5,810	1,050
Netherlands	9,085	11,288	10,325	1,768
U.K.	12,300	12,303	10,451	2,155
West Germany	19,701	24,318	22,415	4,538
Switzerland	5,506	5,680	5,354	1,220
Japan	6,841	6,767	6,100	1,488
CHEMICAL IMPORTS				
U.S.	9,446	8,594	7,485	1,612
Canada	3,691	3,249	3,076	830
EC, nine countries[b]	50,931	56,174	50,562	9,277
Belgium-Luxembourg	5,209	5,972	5,376	983
France	10,366	12,169	9,890	1,786
Italy	7,057	7,993	6,992	1,231
Netherlands	5,655	6,394	5,760	1,131
U.K.	7,900	7,310	7,232	1,385
West Germany	11,9[illegible]0	13,314	12,399	2,177
Switzerland	3,240	3,648	3,156	730
Japan	6,487	6,202	5,178	998

a C&EN estimates. **b** European Communities; historical data have been adjusted to reflect nine countries that were members during 1980 but exclude Greece, which joined in 1981.
Sources: United Nations, Organization of Economic Cooperation & Development, European Communities, individual country data

U.S. TRADE: Biggest customers take less

$ Millions	1981	1980	1979	1978
U.S. CHEMICAL EXPORTS				
Canada	$ 2,478	$ 2,134	$ 1,994	$ 593
Western Europe	6,251	6,429	5,585	1392
Eastern Europe	347	88	200	48
Communist Asia	405	386	125	—
Japan	2,349	1,964	1,652	324
Rest of Asia	2,598	2,782	2,204	300
Middle East	517	459	387	72
Latin America	4,469	4,846	3,814	746
Australasia	778	645	608	121
Africa	642	721	465	125
Other	353	286	272	116
TOTAL	**$21,187**	**$20,740**	**$17,306**	**$3837**
U.S. CHEMICAL IMPORTS				
Canada	$2196	$2494	$2362	$ 397
Western Europe	3930	3953	3449	709
Eastern Europe	131	195	107	9
Communist Asia	126	107	60	—
Japan	956	697	616	196
Rest of Asia	197	163	148	18
Middle East	110	58	48	7
Latin America	669	536	405	69
Australasia	186	206	158	90
Africa	117	62	49	14
Other	828	112	83	103
TOTAL	**$9446**	**$8583**	**$7485**	**$1612**

Source: Department of Commerce

U.S. TRADE, BY PRODUCTS: Exports of fertilizers and plastics ease

	Chemical exports[a]				Chemical imports[b]			
$ Millions	1981[c]	1980[c]	1979[c]	1971	1981[c]	1980[c]	1979[c]	1971
Organic chemicals	$ 5,929	$ 5,697	$ 5,055	$1021	$2974	$2539	$2159	$407
Inorganic chemicals	2,286	2,106	1,712	423	1573	1323	1106	355
Radioactive and associated materials	988	833	937	236	786	989	953	73
Dyeing, tanning, and coloring materials	175	186	177	49	226	194	185	105
Pigments, paints, and varnishes	349	304	273	91	102	89	76	10
Medicinals and pharmaceuticals	2,165	1,932	1,591	420	583	508	441	119
Flavors, perfumes, cosmetics, and toiletries	535	479	399	90	289	301	263	73
Cleaning and polishing materials	396	327	290	88	74	72	73	12
Fertilizers, manufactured	1,735	2,265	1,404	178	1181	1104	976	205
Explosives and pyrotechnics	90	87	62	22	61	59	58	25
Plastics and resins	3,809	3,884	3,241	657	780	646	626	133
Pesticides and disinfectants	544	553	516	d	283	263	190	d
Miscellaneous chemical products	2,187	2,087	1,649	574	534	496	379	95
TOTAL	**$21,187**	**$20,740**	**$17,306**	**$3837**	**$9446**	**$8583**	**$7485**	**$1612**

a Exports of domestic merchandise, including Department of Defense and Grant-Aid shipments; FAS (free alongside ship) value. **b** General imports, FAS value. **c** As a result of statistical reclassification, data for 1979–81 are not comparable directly to those of previous years; C&EN has rearranged earlier data to make them as comparable as possible. **d** Included in miscellaneous.
Source: Department of Commerce

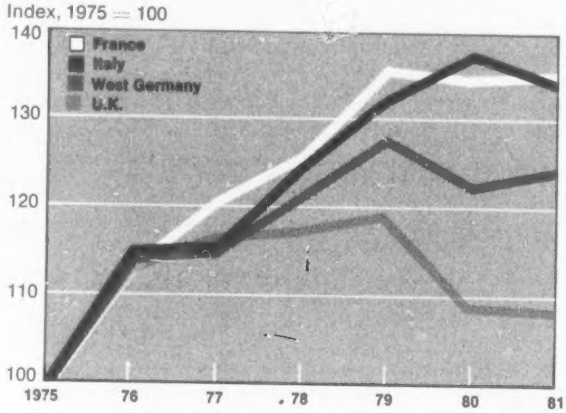
Foreign Chemical Industries Western Europe 6

The business situation was drab last year, by and large, for West European chemical producers. Output, where it had recovered at all from 1980's poor results, generally remained below the levels of 1979. And profits remained hard pressed, even though such leading companies as Akzo, BASF, DSM, and Imperial Chemical Industries showed some improvement from the previous year's depressed results.

Many of the following figures, translated into U.S. dollars, make the year appear even more glum, however, than it actually was. In 1981, all West European currencies were noticeably weaker against the U.S. dollar than in 1980. This tends to exaggerate changes in sales, profits, foreign trade, and investment when stated in dollars.

The situation in Belgium provides an example. Last year, the exchange value of the Belgian franc averaged less than 80% of what it was in 1980. Consequently, although Belgian chemical sales declined about 8% in terms of dollars, in terms of local currency they actually increased 18% to 569 billion francs.

Chemical output weakest in U.K. in 1981



PRODUCTION: Volume declined for most products again last year

Millions of lb	1981	1980	1979	1978	Change 1980-81
FRANCE					
Sulfuric acid	9764	10,894	10,905	10,096	−10%
Hydrochloric acid	1582	1,487	1,575	1,509	6
Phosphoric acid	416	445	447	373	−7
Chlorine	2721	2,765	2,829	2,779	−2
Sodium hydroxide	2904	2,946	3,100	2,948	−1
Sodium carbonate	2867	3,432	3,410	2,977	−16
Ammonia	na	4587	4,730	4,435	—
Sodium sulfate	319	329	334	275	−3
Sulfur	3901	4,174	4,268	4,180	−7
Benzene	1140	1,204	1,392	1,141	−5
Toluene	125	140	190	118	−11
Xylenes	246	172	228	244	43
Ethylene	4176	4,561	4,946	4,228	−8
Propylene	2253	2,174	2,543	2,339	4
Phthalic anhydride	178	169	195	196	5
Methanol	757	757	777	763	0
Formaldehyde	231	254	309	277	−9
Acetone	229	218	271	268	5
Butadiene	596	572	659	631	4
Polyethylene	1987	2,364	2,580	2,158	−16
Polypropylene	678	464	444	319	46
Polystyrene	598	559	590	449	7
Polyvinyl chloride	1619	1,596	1,722	1,463	1
Synthetic rubber	na	1,124	1,190	1,080	—
Phosphate fertilizers (P_2O_5)	2618	2,989	2,872	2,660	−12
U.K.					
Sulfuric acid	6356	7,537	7,696	7,599	−16%
Hydrochloric acid[a]	282	315	348	290	−10
Carbon black	334	385	453	438	−13
Chlorine	1905	2,004	2,262	2,112	−5
Benzene	1799	1,753	2,323	1,947	3
Ethylene	2718	2,409	2,715	2,411	13
Phthalic anhydride	134	101	207	200	33
Thermoplastics	2884[b]	2,911	3,659	3,491	−1
Polyethylene	999	957	1,069	942	4
Polypropylene	433	418	581	642	4
Polystyrene	312	345	466	460	−10
Polyvinyl chloride	693	770	957	902	−10
Synthetic rubber[a]	462[b]	473	609	645	−2
Nitrogen fertilizers (N)[a]	1529	1,516	1,388	1,313	1
Phosphate fertilizers (P_2O_5)[a]	818	759	889	920	8
WEST GERMANY					
Sulfuric acid	8650	8,554	9,082	8,400	1%
Chlorine	6630	6,591	7,075	6,624	1
Sodium carbonate	2616	3,104	3,080	2,699	−16
Ammonia	4316	4,495	4,754	4,301	−4
Sodium sulfate	226	416	458	464	−46
Benzene	2028	2,022	2,213	1,967	0
Toluene	578	572	656	497	1
Xylenes	1071	783	1,085	913	37
Ethylene	6330	6,739	7,803	7,093	−6
Phthalic anhydride	474	493	587	590	−4
Methanol	1507	1,782	1,888	1,771	−15
Polyethylene	2640	3,080	3,472	3,348	−14
Polyvinyl chloride	2026	2,097	2,387	2,213	−3
Synthetic rubber	914	900	981	926	2
Nitrogen fertilizers (N)	2908	3,252	2,961	2,781	−11
Phosphate fertilizers (P_2O_5)	1399	1,595	1,547	1,553	−12

a Manufacturers' sales. b Preliminary. **Sources:** Union des Industries Chimiques, Chemical Industries Association, Verband der Chemischen Industrie

MAN-MADE FIBERS: Noncellulosics made some recovery last year, but cellulosics were down

Millions of lb	1981		1980		1979		1978		1977		Change, 1980–81	
	Non-cellulosics[a]	Cellulosics	Non-cellulosics[a]	Cellulosics	Non-cellulosics[a]	Cellulosics	Non-cellulosics[a]	Cellulosics	Non-cellulosics[a]	Cellulosics	Non-cellulosics	Cellulosics
West Germany	1736	321	1619	304	1725	295	1649	293	1568	290	7%	6%
Italy	1115[b]	133	896[b]	144	988	156	952	190	830	235	24	−8
U.K.	612[c]	298[d]	700[c]	364[d]	838	504	885	472	791	460	−13	−18
Spain	518	111	452	116	466	128	416	133	351	128	14	−4
France	444	118	423	146	493	169	542	163	532	179	5	−19
Benelux countries	228	144	230	148	286	165	306	165	295	156	−1	−3
Switzerland	198	0	186	4	185	7	194	9	171	10	6	—
Ireland	110	0	92	0	86	0	68	0	35	0	20	—
Portugal	78	5	67	6	68	7	62	5	36	6	16	−17
Austria	53	257	56	255	62	242	67	236	57	226	−5	1

a Excludes polypropylene filament unless otherwise indicated. **b** Includes polypropylene filament in 1980 and 1981. **c** Includes cellulose acetate filament. **d** Excludes cellulose acetate filament. **Source:** Comité International de la Rayonne et des Fibres Synthétiques

CHEMICAL INDUSTRY TRENDS: Lower dollar values reflect strength of U.S. currency

$ Billions (U.S.)	1981	1980	1979	1978	1977
WEST GERMANY					
Sales	$51.6	$59.2	$56.0	$44.6	$38.1
Exports	23.8	26.0	24.0	18.4	15.7
Imports	13.3	14.6	13.2	9.5	8.1
Capital spending	3.1	3.8	3.3	2.8	2.4
Production index (1975 = 100)	124.6	122.7	127.9	121.3	115.0
Price index (1975 = 100)	125.2	115.2	106.8	99.2	100.8
Employees (thousands)	548	550	547	548	553
U.K.[a]					
Sales	$37.6	$41.0	$35.6	$27.6	$24.1
Exports	12.3	12.3	10.4	8.1	6.7
Imports	7.9	7.3	7.2	5.3	4.3
Capital spending	2.5	3.2	2.5	2.1	1.4
Production index (1975 = 100)	108.3	109.1	119.2	117.6	116.4
Price index (1975 = 100)	203.3	191.1	165.1	146.7	135.8
Employees (thousands)	395	430	441	439	429
FRANCE[a]					
Sales	$33.4	$37.3	$32.9	$24.7	$21.6
Exports	11.9	13.0	11.5	8.2	6.6
Imports	9.2	10.4	8.9	6.7	5.4
Capital spending	1.2	1.6	1.4	1.1	0.9
Production index (1975 = 100)	135.3	134.4	135.8	125.8	120.5
Price index (1975 = 100)	182.1	159.6	134.1	116.2	111.6
Employees (thousands)	289	296	301	306	307
ITALY					
Sales	$24.1	$28.7	$23.7	$17.9	$15.1
Exports	5.6	5.9	5.2	3.9	3.5
Imports	7.8	9.0	7.9	5.4	4.2
Capital spending	1.1	1.9	1.7	1.3	1.6
Production index (1975 = 100)	133.5	137.5	132.6	125.0	115.4
Price index (1975 = 100)	218.7	195.4	162.0	131.8	125.5
Employees (thousands)	271	289	291	292	293
BELGIUM					
Sales	$15.3	$16.6	$14.4	$10.0	$8.5
Exports	9.2	10.4	9.3	7.2	5.7
Imports	6.4	7.5	6.6	5.0	4.4
Capital spending	na	0.5	0.5	0.5	0.4
Production index (1975 = 100)	129.7	125.4	133.4	123.4	119.3
Price index (1975 = 100)	134.1	121.1	107.1	104.2	104.2
Employees (thousands)	88	90	82	89	92

$ Billions	1981	1980	1979	1978	1977
NETHERLANDS					
Sales	$13.6	$14.3	$13.5	$10.0	$8.5
Exports	11.9	13.0	11.8	8.6	7.3
Imports	7.1	7.9	7.0	5.1	4.3
Capital spending	0.6	0.7	0.6	0.8	1.0
Production index (1975 = 100)	133.0	130.0	136.0	124.0	119.3
Price index (1975 = 100)	143.0	125.0	114.0	103.0	104.9
Employees (thousands)	91	91	92	94	96
SPAIN					
Sales	$15.7	$17.3	$15.4	$11.1	$9.4
Exports	2.3	2.5	2.0	1.2	1.0
Imports	3.1	3.5	3.1	2.1	1.9
Capital spending	0.4	0.7	0.6	0.4	0.4
Production index (1975 = 100)	128.5	132.3	135.0	na	na
Price index (1975 = 100)	232.5	202.0	167.0	na	na
Employees (thousands)	244	244	245	215	215
SWITZERLAND					
Sales	$6.7	$6.8	$6.6	$6.0	$4.3
Exports	5.4	5.6	5.3	4.7	3.4
Imports	3.3	3.7	3.2	2.4	1.9
Production index (1975 = 100)	137.1	130.5	128.4	123.1	118.8
Price index (1975 = 100)	101.8	97.0	90.7	89.1	93.9
Employees (thousands)	63	62	62	62	61
SWEDEN					
Sales	$4.1	$4.3	$3.9	$3.0	$2.8
Exports	1.6	1.7	1.5	1.2	1.0
Imports	2.5	2.9	2.7	2.0	1.8
Capital spending	0.3	0.4	0.4	0.3	0.3
Production index (1975 = 100)	108.0	106.3	111.3	109.2	102.6
Price index (1975 = 100)	167.6	154.0	134.0	118.0	108.8
Employees (thousands)	41	39	40	40	41
NORWAY					
Sales	$1.9	$2.1	na	na	na
Exports	1.5	1.2	$ 0.9	$ 0.7	$ 0.5
Imports	1.0	1.1	1.0	0.8	0.7
Capital spending	0.1	0.2	0.1	0.3	0.4
Production index (1975 = 100)	122	120	118	102	101
Price index (1975 = 100)	141	131	116	103	100
Employees	17	17	17	17	15

a Excludes fibers. **na** = not available. **Sources:** National chemical federations and Conseil Européen des Fédérations de l'Industrie Chimique

COMPANY RESULTS: Profitability remains depressed; employment generally is down

$ Millions	Net sales	Net income	Profit margin	Capital spending	R&D spending	Employees (thousands)
Hoechst (West Germany)						
1981	$15,236.7	$188.5	1.2%	$ 870.4	$670.4	185
1980	16,436.8	305.5	1.9	1053.8	714.8	187
1979	14,797.8	355.2	2.4	893.4	624.0	183
1978	12,156.3	209.5	1.7	734.2	539.7	181
Bayer (West Germany)						
1981	$14,930.1	$228.8	1.5%	$1123.5	$622.1	181
1980	15,837.9	401.1	[illegible]	1461.0	681.9	182
1979	14,208.7	237.7	1.7	1224.0	603.3	181
1978	11,475.4	234.7	2.0	867.8	513.1	179
BASF (West Germany)						
1981	$14,055.8	$162.4	1.2%	$ 911.1	$484.1	117
1980	15,236.8	197.3	1.3	1011.5	545.6	117
1979	14,150.8	338.3	2.4	989.6	487.4	117
1978	10,8[illegible]0.5	211.6	2.0	882.9	417.1	115
Imperial Chemical Industries (U.K.)						
1981	$13,348.9	$389.5	2.9%	$ 833.7	$464.5	132
1980	13,290.7	302.3[a]	2.3	1683.7	493.0	143
1979	11,397.0	970.2	8.5	1613.6	392.8	148
1978	8,700.6	637.2	7.3	1345.5	314.8	151
Montedison (Italy)						
1981	na	na	na	na	na	na
1980	$9,090.0	($523.4)[b]	—	$450.9	$205.6	106
1979	8,222.6	14.4	0.2%	454.9	190.1	115
1978	6,818.2	($317.6)[b]	—	631.6	161.7	127
DSM (Netherlands)						
1981	$7,330.4	$40.4	0.6%	$196.8	$64.0	30
1980	7,496.5	12.6	0.2	258.3	75.4	31
1979	6,343.3	44.3	0.7	266.7	67.2	32
1978	4,631.9	12.0	0.3	464.8	62.5	32
Ciba-Geigy (Switzerland)						
1981	$6,938.3	$265.8	3.8%	$446.4	$549.0	80
1980	7,134.1	182.6	2.6	510.8	561.1	81
1979	5,958.4	197.0	3.3	360.2	496.4	80
1978	4,989.9	201.1	4.0	309.5	425.7	75
Rhône-Poulenc (France)						
1981	$6,599.3	($44.9)[b,c]	—	$447.8	$289.2	89
1[illegible]0	7,139.2	($77.3)[b,d]	—	611.6	354.6	95
1979	7,948.5	186.1	2.3%	517.7	305.9	102
1978	5,657.3	52.9	0.9	3[illegible].9	244.2	107
Akzo (Netherlands)						
1981	$5,790.4	$ 89.6	1.5%	$277.2	$182.0	78
1980	6,257.8	85.4	1.4	324.1	258.8	83
1979	5,977.6	143.8	2.4	299.5	228.9	83
1978	4,938.0	22.7	0.5	200.9	203.7	83

$ Millions	Net sales	Net income	Profit margin	Capital spending	R&D spending	Employees (thousands)
Solvay (Belgium)						
1981	$4,239.7	($20.5)[b]	—	$247.6	$143.4	48
1980	4,734.9	67.6	1.4%	368.0	154.0	49
1979	4,126.2	175.2	4.3	288.7	98.1	46
1978	3,003.5	102.9	3.4	281.4	83.7	45
Hoffmann-La Roche (Switzerland)						
1981	$3,456.7	$129.6	3.7%	$308.7	$414.2	44
1980	3,506.5	138.9	4.0	309.0	415.0	44
1979	3,127.0	131.9	4.2	318.1	389.2	43
1978	2,706.3	112.2	4.2	226.3	355.9	42
BOC International (U.K.)						
1981	$3,088.4	$118.8	3.6%	$308.9	na	42
1980	2,777.9	102.8	3.7	312.6	na	45
1979	2,609.3	94.7	3.6	280.7	na	49
1978	2,295.8	68.5	3.0	256.2	na	56
Sandoz (Switzerland)						
1981	$2,941.8	$115.8	3.9%	$155.6	$236.2	36
1980	2,934.1	121.0	4.1	153.9	248.5	36
1979	2,677.1	104.2	3.9	124.7	232.5	35
1978	2,400.6	87.2	3.6	130.2	211.2	35
CdF Chimie (France)						
1981	$2,169.1	($220.6)[b]	—	$ 49.6	$32.2	12
1980	2,576.8	(130.0)[b]	—	87.5	43.7	13
1979	2,346.4	13	0.1%	110.6	23.5	16
1978	1,501.3	(58.2)[b]	—	200.0	20.4	13
Albright & Wilson (U.K.)						
1981	$1,020.3	$17.0	1.7%	$51.7	na	9
1980	986.0	(4.0)[b]	—	70.5	na	9
1979	838.4	36.1	4.3	69.2	na	10
1978	656.6	44.3	6.7	83.3	na	10
Fisons (U.K.)						
1981	$1,002.8	$ 7.8	0.8%	$17.0	na	10
1980	1,055.1	(3.3)[b]	—	28.1	$32.6	11
1979	919.3	28.1	3.1	36.3	30.6	13
1978	668.5	36.0	5.4	38.4	25.0	13
UCB (Belgium)						
1981	$686.0	$ 6.9	1.0%	$31.0	$18.7	8
1980	786.4	7.5	1.0	38.2	21.9	8
1979	695.4	11.3	1.6	21.0	19.6	8
1978	559.9	1.7	0.3	23.5	18.3	9
Laporte Industries (U.K.)						
1981	$435.5	$12.8	2.9%	$20.3	na	4
1980	457.0	7.4	1.6	37.2	na	5
1979	403.6	17.4	4.3	34.0	na	5
1978	320.7	10.2	3.2	23.0	na	5

a Excludes extraordinary write-off for company restructuring of $348.8 million. b Deficit. c Excludes extraordinary write-off for company restructuring of $16.7 million. d Excludes extraordinary write-off for company restructuring of $383 million. na = not available.

NOTE ON CURRENCY CONVERSION

For monetary statistics in this section, European currencies were converted to U.S. dollars by the following conversion rates:

	$1.00 (U.S.) is equivalent to:									
	Belgium	France	Italy	Netherlands	Norway	Spain	Sweden	Switzerland	U.K.	West Germany
1981	37.13 francs	5.44 francs	1137 lire	2.50 guilders	5.74 crowns	92.31 pesetas	5.06 crowns	1.96 francs	0.492 pound	2.26 marks
1980	29.24 francs	4.23 francs	856 lire	1.99 guilders	4.94 crowns	71.71 pesetas	4.23 crowns	1.67 francs	0.430 pound	1.82 marks
1979	29.32 francs	4.25 francs	831 lire	2.01 guilders	5.06 crowns	67.12 pesetas	4.29 crowns	1.66 francs	0.471 pound	1.83 marks
1978	31.67 francs	4.50 francs	847 lire	2.16 guilders	5.22 crowns	76.00 pesetas	4.52 crowns	1.79 francs	0.521 pound	1.99 marks
1977	35.84 francs	4.91 francs	882 lire	2.45 guilders	5.33 crowns	76.00 pesetas	4.45 crowns	2.40 francs	0.573 pound	2.26 marks

6 Foreign Chemical Industries Japan

Japanese chemical companies, especially those that rely heavily on basic petrochemicals, are between a rock and a hard place. Japan's economy has been struggling. Recovery has been delayed. As a result, domestic demand is down and chemical production reflects this.

Meanwhile, chemical imports have been pouring into Japan but chemical exports aren't increasing as they have in the past. Japan's chemical trade surplus, which exceeded $900 million in 1979, was down to only $354 million last year, according to official government statistics. Industry figures indicate, however, that the chemical trade balance turned into a deficit last year.

The industry needs new investment to replace old and inefficient plants. But chemical companies are hurting on the bottom line, and their fiscal 1982 direct investment is estimated to drop 16%. The industry's basic problem is high-priced naphtha. The government is taking steps to improve the naphtha situation. This should help, but won't cure all of the industry's ills.

WORLD TRADE: Chemical trade surplus lower

$ Millions	1981	1980	1979	1978
Total exports	$152,030	$129,807	$103,032	$97,543
Total imports	143,290	140,528	110,672	79,343
Chemical exports	6,841	6,767	6,100	5,102
Chemical imports	6,487	6,202	5,178	3,763

Source: Ministry of International Trade & Industry

INDUSTRY TRENDS: Chemical output slips

Index, 1975 = 100	1981	1980	1979	Change 1980-81
All chemicals				
Production	144.9	144.7	143.1	0%
Shipments	137.7	139.9	143.6	−2
Inventories	112.7	113.5	101.1	−1
Petrochemicals				
Production	126.4	133.6	147.4	−5
Shipments	126.3	132.1	147.1	−4
Inventories	124.5	132.6	112.5	−6
Plastics				
Production	142.4	149.3	160.4	−5
Shipments	142.6	149.1	161.4	−4
Inventories	111.2	116.2	99.7	−4
Synthetic fibers				
Production	126.0	128.7	129.7	−2
Shipments	131.7	131.7	136.2	0
Inventories	81.3	77.1	80.4	5
Synthetic rubber				
Production	128.1	138.7	140.4	−8
Shipments	120.7	129.7	131.0	−7
Inventories	118.5	125.1	102.0	−5
Fertilizer				
Production	72.6	85.5	90.2	−15
Shipments	79.1	93.6	99.7	−15
Inventories	75.0	72.0	72.1	4
All manufacturing				
Production	147.2	142.8	133.3	3
Shipments	139.9	137.1	130.7	2
Inventories	114.4	110.4	102.6	4

Source: Ministry of International Trade & Industry

PRODUCTION: 1981 is another down year

Thousands of metric tons unless otherwise indicated	1981	1980	1979	1978	Change 1980-81
ORGANIC CHEMICALS					
Acetaldehyde	324	432	583	587	−25%
Acetic acid	365	418	502	518	−13
Acetone	225	235	254	261	−4
Acrylonitrile	477	469	579	609	2
Benzene	1899	2060	2178	2015	−8
Butadiene	518	574	670	658	−10
Butyl alcohol	237	222	252	222	7
Caprolactam	427	443	437	427	−4
Cyclohexane	475	500	509	477	−5
Dioctylphthalate	223	241	259	265	−7
Ethylene	3644	4176	4781	4387	−13
Ethylene dichloride	1650	2060	2110	1837	−20
Ethylene glycol	411	492	572	630	−16
Ethylene oxide	478	529	593	631	−10
Methanol, refined	734	836	940	907	−12
Octyl alcohol, synthetic	239	241	264	254	−1
Phenol, synthetic	214	215	244	249	0
Phthalic anhydride	254	235	284	288	8
Propylene	2538	2636	3096	2963	−4
Propylene glycol	171	163	168	163	5
Styrene	1095	1114	1238	1122	−2
Terephthalic acid	635	601	613	590	6
Toluene	821	889	938	861	−7
Toluene diisocyanate	64	67	66	61	−4
Xylene	1202	1195	1317	1248	1
INORGANIC CHEMICALS					
Ammonium chloride	584	683	753	718	−14
Ammonium sulfate	1815	1879	1883	1929	−3
Calcium carbide	495	550	570	555	−10
Calcium superphosphate	483	591	568	551	−18
Carbon black	557	575	538	489	−3
Chlorine, liquid	764	763	729	651	0
Hydrochloric acid	565	570	528	540	−1
Nitrogen, millions of cu m	5147	4586	4150	3717	12
Oxygen, millions of cu m	6603	6854	7070	6327	−4
Sodium carbonate	1175	1357	1355	1162	−13
Sodium hydroxide	2871	3159	3021	2777	−9
Sodium silicate	692	712	714	654	−3
Sulfuric acid	6572	6777	6581	6437	−3
Titanium dioxide	176	173	185	171	2
PLASTICS					
Phenolic resins	294	304	300	268	−3
Polyethylene	1671	1860	2165	1767	−10
Polypropylene	959	927	1023	745	3
Polystyrene	1183	1129	1227	1032	5
Polyvinyl chloride	1129	1429	1592	1204	−21
DYES, synthetic	50	51	60	54	−2
RUBBER CHEMICALS, organic	43	46	45	41	−7
RUBBER, synthetic	1010	1094	1107	1029	−8

Source: Ministry of International Trade & Industry

COMPANY RESULTS: Profits still hard to come by for Japanese chemical companies

$ Millions	Sales	Net income	Profit margin	Total assets	Employees (thousands)
Mitsubishi Chemical Industries[a]					
1981	$3375	$22.5	0.7%	$3374	8.3
1980	3730	39.8	1.1	3739	8.0
1979	2742	25.5	0.9	2996	8.2
1978	2458	11.0	0.5	3535	8.7
Sumitomo Chemical[b]					
1981	$2880	$22.5	0.8%	$2699	9.6
1980	3167	45.0	1.4	2856	9.7
1979	2202	45.0	2.0	2017	9.9
1978	2078	18.6	0.9	2532	10.8
Asahi Chemical Industry					
1981	$2723	$45.0	1.7%	$2895	13.6
1980	2800	64.4	2.3	2825	13.6
1979	2168	47.2	2.2	2266	13.8
1978	2029	33.9	1.6	2476	14.3
Toray Industries					
1981	$2475	$51.8	2.1%	$2446	13.9
1980	2494	57.9	2.3	2408	13.8
1979	1924	55.7	2.9	2010	13.9
1978	1929	40.3	2.1	2271	14.7
Teijin					
1981	$2160	$24.8	1.1%	$2090	7.2
1980	2111	28.3	1.3	2093	7.3
1979	1613	28.8	1.8	1815	7.2
1978	1611	10.7	0.7	2016	7.7
Mitsui Toatsu Chemicals					
1981	$1935	($22.5)[c]	—	$1858	7.4
1980	1965	(32.8)[c]	—	1941	7.7
1979	1624	36.3	2.2%	1613	7.8
1978	1455	5.4	0.1	1773	8.3
Showa Denko[b]					
1981	$1710	$ 4.5	0.3%	$2102	5.4
1980	2083	35.7	1.7	2276	5.5
1979	1496	27.3	1.8	1475	4.3
1978	1339	17.6	1.3	1850	5.2
Dainippon Ink & Chemicals					
1981	$1688	$19.1	1.1%	$1511	5.9
1980	1654	22.1	1.3	1448	5.8
1979	1301	18.4	1.4	1124	5.5
1978	1248	19.4	1.6	1084	5.5
Mitsubishi Petrochemical[b]					
1981	$1665	$ 0.0	0.0%	$1802	3.9
1980	1900	16.2	0.9	1908	3.8
1979	1366	16.5	1.2	1384	3.9
1978	1213	8.8	0.7	1607	4.3
Sekisui Chemical					
1981	$1350	$15.8	1.2%	$1322	6.1
1980	1420	17.0	1.2	1359	6.1
1979	1195	17.3	1.5	1107	6.0
1978	1128	7.4	0.7	1025	5.9
Mitsui Petrochemical Industries					
1981	$1296	$ 3.6	0.3%	$1455	4.6
1980	1339	10.8	0.8	1474	4.6
1979	1167	23.2	2.0	1127	4.8
1978	914	11.0	1.2	1221	4.8
Unitika					
1981	$ 986	$ 0.0	0.0%	$1135	6.2
1980	1011	4.1	0.4	1229	6.3
1979	785	2.3	0.3	1024	6.5
1978	865	12.0	1.4	1246	6.8

$ Millions	Sales	Net income	Profit margin	Total assets	Employees (thousands)
Toyo Soda Mfg.					
1981	$968	($4.5)[c]	—	$1209	4.9
1980	942	5.2	0.6%	1251	5.0
1979	809	14.5	1.8	977	4.9
1978	721	10.5	1.5	1075	5.0
Kyowa Hakko Kogyo[b]					
1981	$923	$18.5	2.0%	$782	4.9
1980	945	14.9	1.6	749	5.0
1979	694	12.1	1.7	585	4.8
1978	692	13.1	1.9	659	4.8
Mitsubishi Gas Chemical					
1981	$900	$21.2	2.4%	$938	3.8
1980	898	30.7	3.4	948	3.8
1979	714	19.7	2.8	740	3.8
1978	604	10.9	1.8	824	3.8
Denki Kagaku Kogyo					
1981	$891	$ 9.5	1.1%	$1092	4.0
1980	893	10.8	1.2	1078	4.0
1979	761	17.1	2.3	881	4.0
1978	691	9.6	1.4	942	4.1
Mitsubishi Rayon					
1981	$891	$ 9.9	1.1%	$803	3.5
1980	882	11.1	1.3	814	3.5
1979	676	23.6	3.5	703	3.4
1978	701	(5.1)[c]	—	808	3.7
Kuraray					
1981	$887	$6.8	0.8%	$928	6.3
1980	956	7.5	0.8	984	5.7
1979	762	2.7	0.4	824	5.2
1978	790	1.0	0.1	920	5.4
Tokuyama Soda					
1981	$779	$6.3	0.8%	$691	2.5
1980	767	5.2	0.7	682	2.4
1979	616	5.8	0.9	546	2.4
1978	568	6.5	1.1	606	2.4
Japan Synthetic Rubber					
1981	$765	$ 3.2	0.4%	$720	2.7
1980	779	8.2	1.1	761	2.6
1979	542	12.6	2.3	579	2.6
1978	514	6.6	1.3	595	2.7
Hitachi Chemical					
1981	$747	$9.9	1.3%	$451	4.3
1980	746	8.2	1.1	440	4.3
1979	596	8.6	1.4	336	4.1
1978	602	6.6	1.1	365	4.0
Kanegafuchi Chemical Industry					
1981	$743	$ 8.1	1.1%	$583	3.2
1980	776	13.3	1.7	612	3.1
1979	661	16.0	2.4	466	3.0
1978	616	7.9	1.3	534	3.0
Daicel Chemical					
1981	$707	$12.2	1.7%	$656	3.1
1980	677	12.6	1.9	659	3.1
1979	501	15.7	3.1	467	3.1
1978	467	8.6	1.8	461	3.4
Shin Etsu Chemical[d]					
1981	$666	$ 8.1	1.2%	$629	2.4
1980	653	11.5	1.8	600	2.3
1979	551	14.3	2.6	418	2.2
1978	485	7.9	1.6	478	2.3

a Fiscal year starts Jan. 31. **b** Fiscal year starts Dec. 31. **c** Deficit. **d** Fiscal year starts May 31. **Note:** Fiscal years starting March 31 of each year unless otherwise specified. Fiscal year 1981 data are estimates. Results were converted from yen to U.S. dollars on the following basis: fiscal year 1981: $1.00 = 222.4 Y; fiscal year 1980: $1.00 = 212.9 Y; fiscal year 1979: $1.00 = 249.4 Y; fiscal year 1978: $1.00 = 209.3 Y. Year-to-year changes in sales, net income, and assets are affected by fluctuations in the currency exchange rate. **Source:** Toyo Keizai Shinposha

6 Foreign Chemical Industries Canada

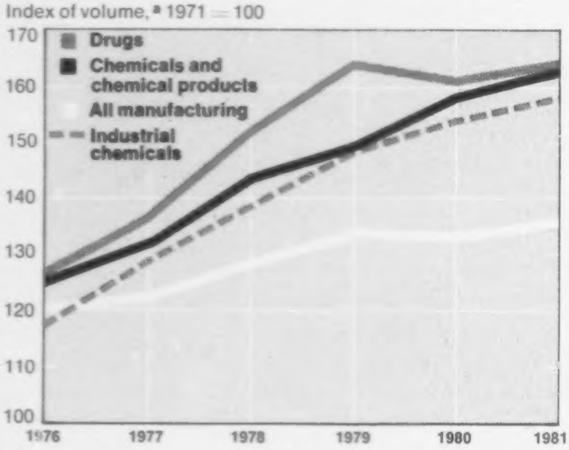
The Canadian chemical industry would rather forget last year and concentrate on the future. The industry enjoys an ample supply of potentially inexpensive hydrocarbons that is the envy of industries in other countries. But Canadian chemical companies learned the hard way last year that feedstock supply alone doesn't guarantee big profits.

Three ingredients were missing. One was feedstock that was as inexpensive as chemical companies had expected. Government energy policies pushed feedstock costs unexpectedly high.

Meanwhile, the Canadian economy turned sour in the second half of the year. Demand dropped and producers weren't able to pass through raw material price increases to their customers.

And although chemical exports, which have become an important element in Canadian chemical marketing, increased, generally poor international markets kept prices—and margins—low. As a result, profits of many Canadian chemical companies dropped substantially.

Chemical output rises, but pace slows



a Gross domestic product. **Source:** Statistics Canada

TRADE BALANCE: Total surplus narrows . . .

$ Millions (Canadian)	1981	1980	1979	1978
Exports[a,b]	$80,895	$74,259	$64,317	$50,102
Imports[c]	78,665	69,128	62,871	52,259
Trade balance	2,230	5,131	1,446	−2,157

. . . but chemical surplus continues to expand

$ Millions (Canadian)	1981	1980	1979	1978
Chemical exports[b,d]	$4634	$4055	$3322	$2351
Chemical imports	3811	3354	3240	2618
Chemical trade balance	823	701	82	−267

a Includes re-exports. b Values as declared on export documents; may include shipping costs. c Values as established for duty purposes. d Domestic exports only. **Source:** Statistics Canada

PRODUCTION: Plastics chalk up best gains

Thousands of metric tons	1981	1980	1979	1978	Change 1980–81
Ammonia, anhydrous	2654.0	2555.6	2105.3	2642.9	4%
Ammonium nitrate	911.0	873.5	914.5	959.9	4
Ammonium phosphate	1355.0	1466.2	1335.7	1299.5	−8
Benzene	566.5	560.0	492.9	na	1
Chlorine	1292.0	1301.8	1031.4	1037.0	−1
Ethylene	1330.2	1196.7	1013.8	910.2	11
Hydrochloric acid	185.7	176.8	154.4	170.4	5
Phosphoric acid, 100% P_2O_5	743.8	807.9	747.7	610.5	−8
Polyesters, unsaturated	26.4	27.4	32.0	20.3	−4
Polyethylene	673.3	641.7	628.2	477.5	5
Polystyrene	122.6	109.8	123.8	98.8	12
Polyvinyl chloride	222.1	190.4	149.4	124.7	17
Sodium chlorate	254.8	244.6	223.8	219.5	4
Sodium hydroxide	1457.8	1495.2	1138.3	1142.2	0
Sulfuric acid, 100%	4116.9	4295.4	3666.1	3594.5	−4
Urea	1303.5	1274.3	1211.7	1341.7	2

na = not available. **Source:** Statistics Canada

COMPANY RESULTS: Profit margins shrink

$ Millions (Canadian)[a]	Sales	Net income[b]	Profit margin	Capital expenditures	Employees (thousands)
C-I-L INC.[c]					
1981	$1149.9	$54.3	4.7%	$94.1	7.8
1980	1004.2	51.5	5.1	70.2	8.3
1979	880.0	36.3	4.1	84.4	8.0
1978	746.9	26.4	3.5	97.5	8.0
CELANESE CANADA					
1981	$373.0	$20.4	5.4%	$87.7	3.5
1980	336.2	24.2	7.2	55.1	4.2
1979	353.6	21.2	6.0	24.4	4.4
1978	290.7	7.4	2.4	18.2	4.6
DOW CHEMICAL CANADA[d]					
1981	$837.0	$67[e]	8.0%[e]	$149	4.0
1980	751.0	59[e]	8.1[e]	113	4.0
1979	629.7	50[e]	7.9[e]	292	3.8
1978	438.5	27.6[e]	6.3[e]	250.4	3.3
DU PONT CANADA					
1981	$1139.1	$33.5	2.9%	$47.0	6.1
1980	995.3	42.6	4.3	53.2	5.9
1979	879.6	58.9	6.7	23.3	5.6
1978	661.9	10.2	1.5	10.7	5.4
UNION CARBIDE CANADA					
1981	$827.3	$36.1	4.4%	$100.0	5.0
1980	794.8	79.6	10.0	58.9	5.0
1979	685.9	57.8	8.4	30.1	4.8
1978	528.2	20.1	3.8	46.3	4.7

a Unless otherwise indicated. b Excluding extraordinary gains and losses. c Name changed from Canadian Industries Ltd. on Jan. 1, 1980. d Amounts in U.S. dollars. e Before taxes.

SHIPMENTS: Petroleum sets the pace but growth in chemicals is a bit above average

$ Millions (Canadian)	Shipments, monthly average 1981	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971	Average annual change 1980–81	1971–81
All manufacturing	$15,691.3	$13,913.2	$12,520.7	$10,743.7	$9070.6	$8190.4	$7371.6	$6871.2	$5563.1	$4687.2	$4189.5	12.7%	14.1%
Chemicals and chemical products	1,056.7	929.7	791.9	663.3	535.6	475.3	425.6	383.9	291.9	246.2	231.8	13.7	16.4
Petroleum and coal products	1,597.7	1,206.7	1,003.0	837.9	711.0	576.8	496.1	432.1	256.1	203.4	176.2	32.4	24.5
Rubber and plastics products	370.7	334.7	300.3	250.1	211.0	192.7	162.9	152.8	131.4	109.7	97.0	10.8	14.2
Paper and allied products	1,265.4	1,185.5	1,032.0	839.5	744.8	685.7	594.2	639.7	439.2	367.8	333.4	6.7	14.2

Source: Statistics Canada

PRICES: Increases for industrial chemicals are greater than for industrial products as a whole

Industry selling price indexes, 1971 = 100	Annual average 1981	1980	1979	1978	1977	1976	1975	1974	1973	Annual change 1980–81	1971–81
All manufacturing industries	272.2	247.2	217.8	190.4	174.3	161.6	153.7	138.1	116.1	10.1%	11.0%
Chemicals and chemical products	286.2	251.6	214.8	189.3	175.9	167.2	160.3	137.1	106.5	13.8	11.4
Industrial chemicals—inorganic	313.9	275.3	234.1	204.1	188.4	179.7	169.5	133.5	107.7	14.0	11.8
Acetylene, compressed	266.3	232.9	213.2	191.2	170.7	163.7	150.6	116.2	102.9	14.3	9.9
Caustic soda	383.8	281.0	240.1	221.4	210.7	195.7	169.5	120.2	107.0	36.6	14.4
Chlorine	274.8	248.4	207.9	189.2	180.5	163.3	144.4	114.1	104.3	10.6	10.9
Oxygen, gas and liquid	215.6	202.4	191.8	174.6	156.8	152.1	136.0	121.2	108.3	6.5	7.2
Industrial chemicals—organic	410.2	354.7	289.0	249.8	228.1	214.2	201.2	170.0	107.8	15.6	13.9
Plastics and synthetic resins	294.7	274.4	239.7	206.4	193.3	187.4	181.6	156.0	104.2	7.4	9.4
Alkyd	196.5	176.9	158.4	137.5	129.4	131.4	135.1	134.8	109.4	11.1	8.4
Phenol formaldehyde	337.6	332.8	300.9	233.6	232.1	235.6	240.9	214.1	111.4	1.4	7.5
Polyethylene	326.9	315.3	268.9	223.2	220.3	221.6	213.2	166.3	103.2	3.7	8.1
Fertilizers, mixed	290.5	280.3	229.1	191.0	180.2	176.9	204.0	167.5	117.2	3.6	10.4
Drugs	189.7	169.5	153.1	140.4	131.4	127.0	121.1	109.9	103.5	11.9	8.3
Paint and varnish	280.3	239.8	202.3	183.0	172.8	161.9	153.9	131.9	108.2	16.9	11.6
Pigments and dry colors	304.4	260.0	219.6	189.7	175.3	164.9	153.4	136.0	103.7	17.1	13.1
Soaps and cleansing compounds	209.7	189.1	169.5	151.2	141.1	134.5	132.1	118.0	105.3	10.9	9.2

Source: Statistics Canada

CHEMICAL IMPORTS: Big gains for most

$ Millions (Canadian)[a]	1981	1980	1979	Change 1980–81
Inorganic chemicals	$ 401.1	$ 344.1	$ 353.2	17%
Organic chemicals	1087.3	930.1	895.3	17
Fertilizers and fertilizer materials	158.9	134.9	135.1	18
Synthetic and reclaimed rubber	159.8	126.3	118.9	27
Plastics materials	605.1	537.2	564.4	13
Plastic film and sheet	242.1	192.2	181.7	26
Other plastics basic shapes and forms	154.2	128.5	135.5	20
Dyes, except dyeing intermediates	76.0	79.8	81.7	−5
Pigments, lakes, and toners	64.4	53.5	62.1	20
Paints and related products	98.4	86.2	94.9	14
Other chemical products	763.3	741.4	617.5	3
TOTAL	**$3810.7**	**$3354.2**	**$3240.3**	14%

[a] Values as established for duty purposes. **Source:** Statistics Canada

CHEMICAL EXPORTS: Organics up sharply

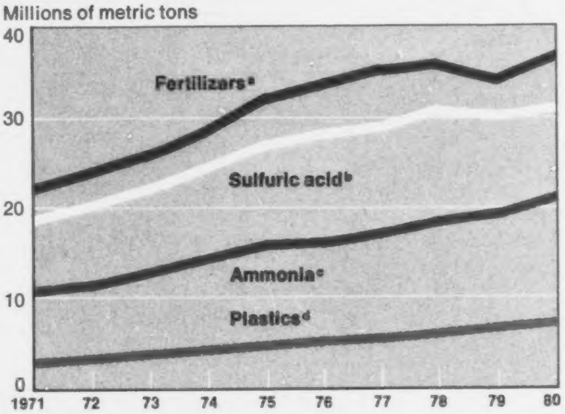
$ Millions (Canadian)[a]	1981	1980	1979	Change 1980–81
Chemical elements	$ 181.0	$ 160.4	$ 146.0	13%
Other inorganic chemicals	1052.4	947.3	839.7	11
Organic chemicals	1185.9	923.9	704.8	28
Fertilizers and fertilizer materials	1345.6	1253.8	987.3	7
Synthetic rubber and plastic materials	514.6	467.0	367.3	10
Plastics basic shapes and forms	149.0	123.5	119.3	21
Other chemical products	205.6	178.9	157.6	15
TOTAL	**$4634.0**	**$4054.7**	**$3321.8**	**14%**

[a] Domestic exports only. Values as declared on export documents; may include shipping costs.
Source: Statistics Canada

6 Foreign Chemical Industries Eastern Europe

In 1981, economic growth continued to decelerate in Eastern Europe as a whole, as it has since 1977, generally falling short even of the lower targets set under current five-year plans. Industrial output for the U.S.S.R. and its six East European allies was up just 2% (the target was 4%). Bulgaria, East Germany, and Hungary increased production more than in 1980, but the area's average was lowered especially by Poland's chaotic economy, where production was down 13%. Excluding Poland, area production was up 3%. The chemical and rubber industries performed strongest in Bulgaria (up 11%) and the Soviet Union (up 5%), where both were exactly on target.

Chemical production in Eastern Europe speeded up in 1980



[a] As N, P_2O_5, and K_2O. [b] 100% H_2SO_4. [c] Nitrogen content. [d] Including resins for man-made fibers in U.S.S.R. **Note:** Data for U.S.S.R., Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, and Romania.
Source: Central Intelligence Agency

MAN-MADE FIBERS: Results mixed in 1981

Production, millions of lb	1981[a]	1980	1979	1978	Change 1980–81
NONCELLULOSIC FIBERS[b]					
Bulgaria	117	110	106	102	6%
Czechoslovakia	183	168	159	163	9
East Germany	330	306	292	281	8
Hungary	48	39	40	41	23
Poland	262	348	338	335	−25
Romania	320	300	309	287	7
U.S.S.R.	1345	1213	1049	1047	11
TOTAL	**2605**	**2484**	**2293**	**2256**	5%
CELLULOSIC FIBERS					
Bulgaria	86	80	73	68	8%
Czechoslovakia	116	121	128	156	−4
East Germany	373	372	364	360	0
Hungary	17	18	19	20	−6
Poland	141	190	185	206	−26
Romania	174	140	143	138	24
U.S.S.R.	1475	1433	1400	1400	3
TOTAL	**2382**	**2354**	**2312**	**2348**	1%

[a] Preliminary figures. [b] Excluding olefins and textile glass. **Source:** Textile Economics Bureau

PRODUCTION GROWTH: Slowdown persists

% annual change in gross output	1981	1980	1979	1978	1977
U.S.S.R. and East Europe					
All industry	2.1%	3.4%	3.7%	5.1%	6.1%
Bulgaria					
All industry	5.6	4.0	5.4	6.9	6.8
Chemicals and rubber	11.1	11.1	9.1	10.0	12.4
Czechoslovakia					
All industry	2.0	3.3	3.7	5.0	5.5
Chemicals and rubber	0.1	4.8	3.3	na	na
East Germany					
All industry[a]	5.1	4.7	4.8	3.7	5.4
Chemicals and rubber	na	3.8	4.0	6.0	4.3
Hungary					
All industry	2.3	−2.1	3.0	4.9	6.6
Chemicals and rubber	2.0	−2.1	6.1	10.7	6.9
Poland					
All industry	−12.6[b]	0.0	2.7	4.9	6.9
Chemicals and rubber	na	0.4	2.3	3.9	4.4
Romania					
All industry	2.6	6.1	8.0	9.6	12.5
Chemicals and rubber	4.0	6.8	1.4	10.6	13.9
U.S.S.R.					
All industry[c]	3.4	3.6	3.4	4.8	5.7
Chemicals and rubber[c]	5.0	5.6	2.3	6.0	6.5
All industry[d]	na	2.9[e]	3.0	3.5	4.0
Chemicals and rubber[d]	na	5.2[e]	0.2	3.6	5.2

[a] Industrial commodity production. [b] Sales at current prices. [c] Figures based on official Soviet statistics. [d] Figures based on Central Intelligence Agency estimates, giving lower results because of postulated upward bias in official figures. [e] Preliminary figure. **na** = not available. **Sources:** United Nations Economic Commission for Europe, based on official national statistics, Central Intelligence Agency

AGRICULTURAL CHEMICALS: Output off in Poland, Czechoslovakia, Bulgaria

Thousands of metric tons	1981	1980	1979	1978	1977
Bulgaria					
Fertilizer supply[a]	733[b]	830	820	738	742
Pesticide supply	na	40.0	34.8	35.3	26.3
Czechoslovakia					
Fertilizer supply[a]	1,700	1,730	1,745	1,748	1,633
East Germany					
Fertilizer supply[a]	na	1,637	1,713	1,670	1,670
Pesticide supply	na	27.0	26.7	25.3	24.5
Hungary					
Fertilizer supply[a]	na	1,399	1,502	1,539	1,511
Poland					
Fertilizer supply[a]	3,490[b]	3,635	3,567	3,606	3,586
Pesticide supply	na	na	44.7	49.8	57.1
Romania					
Fertilizer supply[a]	1,600	1,185	1,431	1,480	1,128
U.S.S.R.					
Fertilizer supply[a]	19,169[b]	18,763	17,365	18,420	18,034
Pesticide supply	na	512	na	na	na

[a] Nutrient content. [b] Estimated. **na** = not available. **Sources:** United Nations Economic Commission for Europe, based on official national statistics, Department of Agriculture

PRODUCTION: Growth continues for fertilizers and plastics in Eastern Europe

Thousands of metric tons, unless otherwise noted	1981[a]	1980	1979	1978	1977
U.S.S.R.					
Sulfuric acid, 100%	24,100	23,030	22,364	22,411	21,104
Mineral fertilizers (gross weight)	108,000	103,858	94,523	97,976	96,752
Mineral fertilizers[b]	26,000	24,774	22,137	23,653	23,493
Nitrogen[b]	na	10,239	9,151	9,299	9,114
Phosphate[b,c]	na	6,471	6,344	6,153	6,024
Potassium[b]	na	8,064	6,635	8,193	8,347
Synthetic ammonia[d]	na	13,764	12,278	11,462	10,744
Sodium carbonate, 100%	na	4,800	4,782	4,858	4,876
Plastics[e]	4,100	3,638	3,478	3,516	3,309
Sodium hydroxide, 100%	2,800	2,755	2,680	2,763	2,658
Synthetic rubber[f]	na	1,880	1,867	1,795	1,700
Rubber tires[g] (thousands of units)	60,500	60,100	59,981	59,018	57,400
Pesticides	504	470	475	491	487
BULGARIA					
Sulfuric acid, 100%	na	859	998	974	860
Mineral fertilizers[b]	na	947	959	968	984
Nitrogen[b]	na	730	677	685	705
Phosphate[b]	na	217	282	283	279
Synthetic ammonia[d]	na	1,026	951	960	995
Plastics	na	250	200	178	169
Sodium hydroxide, 100%	na	161	107	102	96
Synthetic rubber	na	30	30	25	25
Rubber tires[g] (thousands of units)	na	1,982	1,752	1,734	1,830
CZECHOSLOVAKIA					
Sulfuric acid, 100%	na	1,284	1,253	1,195	1,276
Mineral fertilizers[b]	na	1,182	1,140	1,176	1,178
Nitrogen[b]	na	618	591	625	605
Phosphate[b,c]	na	361	358	367	389
Potassium[b,h]	na	203	199	191	184
Synthetic ammonia[d]	na	841	804	812	791
Plastics	913	894	853	810	738
Sodium hydroxide, 100%	na	326	312	311	312
Synthetic rubber	na	59	60	59	59
Rubber tires[g] (thousands of units)	na	6,714	6,581	6,439	6,341
EAST GERMANY					
Sulfuric acid, 100%	na	950	952	971	972
Mineral fertilizers[b]	na	4,773	4,740	4,628	4,470
Nitrogen[b]	na	940	875	892	838
Phosphate[b,c]	na	411	411	413	403
Potassium[b]	na	3,422	3,395	3,323	3,229
Synthetic ammonia[d]	na	1,159	1,079	1,137	1,130
Plastics	na	800	779	762	734
Sodium hydroxide, 100%	na	626	548	415	423
Synthetic rubber	na	170	165	145	147
Rubber tires[g] (thousands of units)	na	7,068	6,890	6,728	6,652
HUNGARY					
Sulfuric acid, 100%	na	614	613	690	678
Mineral fertilizers[b]	na	894	850	855	788
Nitrogen[b]	na	599	550	534	514
Phosphate[b]	na	150	165	185	165
Potassium[b,h]	na	145	143	136	109
Synthetic ammonia[d]	na	900	803	746	729
Plastics	311	328	294	213	148
Sodium hydroxide, 100%[i]	na	188	194	146	97
Rubber tires[g] (thousands of units)	na	870	750	773	814
POLAND					
Sulfuric acid, 100%	na	2,964	2,983	3,172	3,268
Mineral fertilizers[b]	na	2,239	2,431	2,621	2,610
Nitrogen[b]	na	1,295	1,376	1,470	1,521
Phosphate[b]	na	842	931	1,026	966
Potassium[b,h]	na	105	110	125	123
Synthetic ammonia[d]	na	1,438	1,530	1,616	1,665
Plastics	na	549	440	467	463
Sodium hydroxide 100%	na	415	436	469	440
Synthetic rubber	na	118	130	126	119
Rubber tires[g] (thousands of units)	na	8,743	8,500	7,852	7,457
ROMANIA					
Sulfuric acid, 100%	na	1,850	1,750	1,655	1,523
Mineral fertilizers[b]	2,640	2,451	2,522	2,461	1,981
Nitrogen[b]	na	1,689	1,738	1,723	1,381
Phosphate[b]	na	689	709	660	548
Potassium[b,h]	na	73	75	78	52
Synthetic ammonia[d]	na	2,267	2,333	2,259	1,793
Plastics	na	579	516	552	543
Sodium hydroxide, 100%	na	705	704	725	735
Synthetic rubber	na	150	149	148	136
Rubber tires[g] (thousands of units)	na	5,060	4,691	4,690	4,372

a Approximate figures. b Nutrient content basis, as N, P_2O_5, or K_2O. c Including production of ground phosphate rock for direct applications and phosphate animal feeds. d Nitrogen content. e Including resins for man-made fibers. f Estimated. g For all motor vehicle tires, excluding aircraft and bicycle tires. h Imported potash added to domestically produced nitrogen and phosphate to form multinutrient fertilizer. i Including regenerated NaOH. na = not available. **Sources:** Central Intelligence Agency, Department of Commerce, Department of Agriculture, United Nations Economic Commission for Europe (based on official national statistics)

SOVIET FOREIGN TRADE: After steady growth, exports and imports of chemicals turn down

$ Millions	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971
Exports[a]	$79,377	$76,470	$64,913	$52,395	$45,227	$37,269	$33,401	$27,374	$21,332	$15,409	$13,792
Imports[a]	73,158	68,477	57,961	50,795	40,926	38,212	37,070	24,861	20,980	16,104	12,467
Trade balance	6,219	7,993	6,952	1,600	4,301	−943	−3,669	2,513	352	−695	1,325
Chemical exports[a]	na	1,119	1,606	1,284	1,063	939	1,027	887	549	439	396
Chemical imports[a]	na	1,822	2,803	2,188	1,850	1,668	1,747	1,448	954	868	702
Chemical trade balance	na	−703	−1,197	−904	−787	−729	−720	−561	−405	−429	−306

a Free on board. na = not available. Sources: Central Intelligence Agency, Department of Commerce, based on official Soviet statistics and exchange rates

6 Western Pacific

CHINA

PRODUCTION: Slower growth in 1981 for most major products

Thousands of metric tons	1981	1980	1979	1978	Change 1980–81
Ammonia[a]	11,990	12,150	10,727	9287	−1.3%
Fertilizer[b]	12,390	12,320	10,654	8691	0.6
Nitrogen (N)	9,860	9,990	8,821	7637	−1.3
Phosphate (P_2O_5)[c]	2,510	2,310	1,817	1033	8.7
Potash (K_2O)	20	20	16	21	0
Sulfuric acid	7,810	7,640	7,000	6610	2.2
Sodium hydroxide	1,923	1,923	1,826	1640	0
Sodium carbonate	1,652	1,613	1,486	1329	2.4
Calcium carbide	1,510	1,520	1,407	1237	−0.7
Plastics	916	898	793	679	2.0
Insecticides	484	537	537	533	−9.9
Ethylene	500	490	435	380	2.0
Synthetic detergents	478	393	397	324	21.6
Man-made fibers	527	450	326	285	17.1
Pharmaceuticals	37	40	42	41	−7.5

a Nitrogen content of ammonia produced for fertilizer. b Nutrient content. c Including production of ground phosphate rock for direct application and phosphate animal feeds. **Sources:** State Statistical Bureau of the People's Republic of China, Central Intelligence Agency

CHEMICAL IMPORTS: Fertilizers are biggest

$ Millions[a]	1980	1979	1978	Change 1979–80
Fertilizers[b]	$ 821	$ 594	$ 465	38%
Nitrogenous fertilizer	501	496	354	1
Chemical elements and compounds	546	411	382	33
Organic chemicals	394	258	265	53
Plastic materials, resins	378	158	137	139
Dyeing, tanning, and coloring materials	79	88	70	−10
Medicinal products	19	13	9	46
Essential oils, perfume, and cleansing materials	9	10	10	−9
Mineral tar and crude chemicals[c]	0	11	12	−99
Other chemicals[d]	179	159	100	13
TOTAL	**$2031**	**$1444**	**$1185**	**41%**

a Free on board. b Manufactured. c From coal, oil, and natural gas. d Includes explosives and pyrotechnic products, and chemical materials and products not elsewhere specified. **Source:** Central Intelligence Agency, estimated from data reported by China's trade partners

CHEMICAL EXPORTS: Top $1 billion

$ Millions[a]	1980	1979	1978	Change 1979–80
Chemical elements and compounds	$ 488	$276	$141	77%
Organic chemicals	281	168	85	67
Medicinal products	186	114	79	63
Essential oils, perfume, and cleansing materials	104	82	67	27
Explosives and pyrotechnic products	95	72	49	32
Plastic materials, resins	77	50	12	54
Dyeing, tanning, and coloring materials	66	46	35	45
Mineral tar and crude chemicals[b]	28	9	3	208
Fertilizers[c]	2	1	1	42
Other chemical products	184	129	84	43
TOTAL	**$1230**	**$779**	**$471**	**58%**

a Free on board. b From coal, oil, and natural gas. c Manufactured. **Source:** Central Intelligence Agency, estimated from data reported by China's trade partners

TAIWAN

INDUSTRY TRENDS: Chemical growth slows

Industrial production indexes, 1976 = 100	1981	1980	1979	1978	Change 1980–81
All manufacturing	169.3	163.2	153.0	142.8	4%
Chemical materials	205.1	201.2	189.1	165.3	2
Basic chemicals	152.5	150.2	148.5	126.1	2
Petrochemicals	262.3	254.4	242.0	194.1	3
Fertilizers	124.0	134.6	127.9	125.9	−8
Synthetic fibers	197.4	187.7	174.5	159.7	5
Plastics and resins	210.4	214.5	197.5	176.6	−2
Chemical products	176.7	163.9	161.0	139.2	8

Source: Council for Economic Planning & Development, Taiwan

FOREIGN TRADE: Big gains for chemicals

$ Millions	1981[a]	1980	1979	1978
Exports[b]	$22,611	$19,811	$16,103	12,687
Imports[c]	21,200	19,733	14,774	11,027
Trade balance	1,411	78	1,330	1,660
Chemical exports[b]	981	494	356	275
Chemical imports[c]	2,725	2,024	1,817	1,305
Chemical trade balance	−1,744	−1,530	−1,461	−1,030

a Estimated. b Free on board. c Includes cost, insurance, and freight. **Source:** Council for Economic Planning & Development, Taiwan

PRODUCTION: Lower for several chemicals

Thousands of metric tons, unless otherwise noted	1981	1980	1979	1978	Change 1980–81
Fertilizers[a]	na	2,092	1,979	1,959	na
Man-made fibers	687	633	587	540	9%
Polyvinyl chloride	456	454	407	389	0
Synthetic detergents	94	104	105	86	−9
Benzene[b]	137	145	153	129	−5
Ethylene	443	458	445	366	−3
Ethylene glycol	156	133	118	51	18
Propylene	204	213	205	164	−4
Toluene[b]	172	153	134	95	12
Vinyl chloride	411	405	317	320	2
Xylene[b]	277	311	285	131	−11
Ammonia, anhydrous	494	504	476	534	−2
Ammonium sulfate	504	539	556	541	−6
Calcium superphosphate	226	207	208	175	9
Hydrochloric acid	184	179	180	180	3
Oxygen[c]	174	159	141	107	9
Sodium hydroxide	357	400	420	362	−11
Sulfuric acid	819	769	777	685	6
Urea	285	343	312	366	−17

a In terms of 20% N, 18% P_2O_5, and 50% K_2O fertilizer. b Millions of liters. c Millions of cubic meters. na = not available. **Source:** Council for Economic Planning & Development, Taiwan

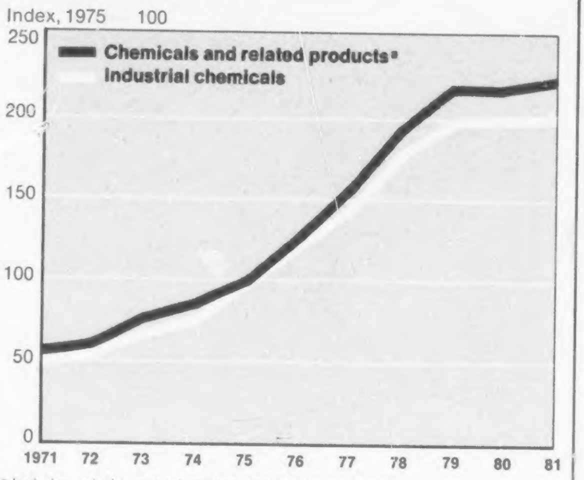
KOREA

INDUSTRY TRENDS: Chemicals gain modestly

Index, 1975 = 100	1981	1980	1979	Change 1980–81
Chemicals, petroleum, coal, rubber, and plastic products				
Production	223.0	219.0	219.7	2%
Shipments	195.2	194.3	191.6	0
Inventories	224.0	236.3	157.7	−5
Industrial chemicals				
Production	213.5	207.0	200.8	3
Shipments	227.5	217.7	193.7	4
Inventories	220.3	198.2	146.2	11
Other chemical products				
Production	244.2	240.6	260.9	1
Shipments	243.7	236.3	251.8	3
Inventories	325.4	309.0	289.6	5
Rubber products				
Production	243.8	273.1	244.0	−11
Shipments	255.0	278.0	245.5	−8
Inventories	260.2	336.4	152.8	−23
Plastic products				
Production	212.8	229.6	293.7	−7
Shipments	215.6	234.2	292.5	−8
Inventories	323.0	201.0	300.7	61
All manufacturing				
Production	238.8	215.9	220.1	11
Shipments	234.1	212.7	212.0	10
Inventories	231.0	219.0	159.7	5

Source: Korean Bureau of Statistics

Korean chemical output grows at slower pace in recent years



a Includes petroleum, coal, rubber, and plastic products.
Source: Korean Bureau of Statistics

FOREIGN TRADE: Chemical exports decline

$ Millions	1981	1980	1979	1978
Exports[a]	$21,254	$17,505	$15,056	$12,711
Imports[b]	26,131	22,292	20,339	14,972
Trade balance	−4,877	−4,787	−5,283	−2,261
Chemical exports	682	780	532	341
Chemical imports	2,109	1,835	2,009	1,298
Chemical trade balance	−1,427	−1,055	−1,477	−957

a Free on board. **b** Includes cost, insurance, freight. **Source:** Korean Bureau of Statistics

PRODUCTION: Agricultural chemicals slump

Thousands of metric tons	1981	1980	1979	1978	Change 1980–81
Sulfuric acid	1294	1683	1645	1461	−23%
Complex fertilizers	1211	1439	1696	1658	−16
Ammonia	908	1031	1169	1091	−12
Urea fertilizers	1070	973	1166	1186	10
Polyvinyl chloride	287	232	192	131	24
Sodium carbonate	202	222	204	176	−9
Fused phosphate	94	121	125	124	−23
Insecticides	52	72	101	80	−28
Synthetic detergents	58	64	70	64	−9

Source: Korean Bureau of Statistics

AUSTRALIA

PRODUCTION: Generally lower last year

Thousands of metric tons	1981	1980	1979	1978	Change 1980–81
Chemicals and acids					
Hydrochloric acid	59	63	58	53	−6%
Nitric acid	182	180	169	160	1
Sulfuric acid	1963	2175	1922	1799	−10
Ammonium sulfate	211	203	212	217	4
Superphosphate[a]	3770	4202	3646	3388	−10
Plastics and resins	747	727	614	522	3
Synthetic detergents	236	239	220	217	−1
Unsupported plastics film, sheeting	126	132	118	106	−4
Polyethylene, low density	81	86	74	65	−5
Polyvinyl chloride	18	17	16	16	2

a Includes double and triple superphosphates and ammonium phosphate expressed in terms of single phosphate (22% P_2O_5 equivalent). **Note:** Years ending June 30. **Source:** Australian Bureau of Statistics

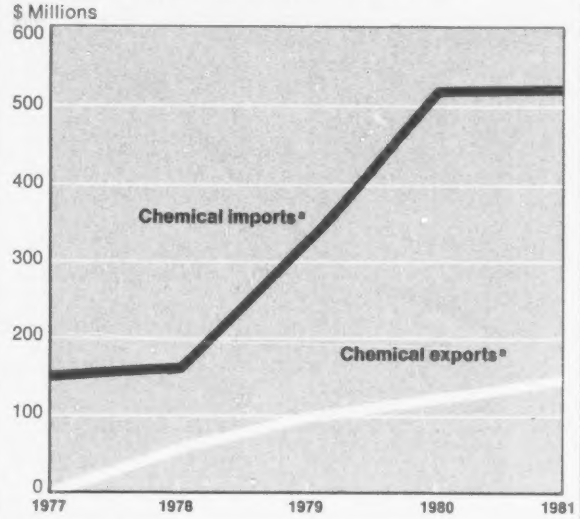
FOREIGN TRADE: Chemical deficit widens

$ Millions	1981	1980	1979	1978
Exports[a,b]	$22,328	$21,078	$16,221	$13,865
Imports[c]	22,067	18,116	15,662	12,619
Trade balance	261	2,962	559	1,246
Chemical exports[a,b]	463	424	351	249
Chemical imports[c]	1,847	1,764	1,368	1,119
Chemical trade balance	−1,384	−1,340	−1,017	−870

a Free on board. **b** Includes re-exports. **c** Values as established for duty purposes, free-on-board basis. **Note:** Years ending June 30. **Source:** Australian Bureau of Statistics

MEXICO

Chemical imports outpace exports



a Pemex trade in primary petrochemicals only. **Source:** Petróleos Mexicanos

PRODUCTION: Petrochemicals up sharply

Thousands of metric tons[a]	1981	1980	1979	1978	Change 1980-81
Acetaldehyde	122.2	47.6	48.8	45.3	157%
Acrylonitrile	54.0	54.3	23.3	19.1	−1
Ammonia, anhydrous	2183.2	1883.2	1652.7	1579.2	16
Benzene	76.5	79.3	70.5	78.8	−4
Butadiene	12.3	17.0	17.3	18.3	−28
Cyclohexane	44.1	39.7	29.2	37.6	11
Cumene[b]	1.6	0	0	0	—
Dichloroethane	116.9	106.3	97.3	96.5	10
Dodecylbenzene	59.5	55.4	62.8	66.3	7
Ethane	1337.4	632.2	607.5	496.1	112
Ethylbenzene	29.1	29.3	32.6	36.6	−1
Ethylene	378.3	365.5	342.7	258.0	4
Ethylene oxide	48.5	29.7	24.3	26.3	63
Hexane	65.6	60.1	53.4	29.2	9
Hydrochloric acid	33.2	36.1	31.9	34.7	−8
Isopropyl alcohol	15.6	12.6	0.6	1.4	25
Methanol	179.7	173.6	147.0	102.8	4
Nitrogen[b]	29.5	0	0	0	—
Oxygen[b]	159.1	0	0	0	—
Polyethylene, high density	78.1	66.9	58.4	3.3	17
Polyethylene, low density	91.2	91.4	95.6	96.4	0
Propylene	156.2	136.9	159.9	138.4	14
Propylene tetramer	35.4	35.8	43.0	39.2	−1
Styrene	32.9	31.3	31.2	37.8	5
Sulfur, recovered	425.5	402.4	249.4	168.0	6
Toluene	131.6	124.9	107.9	123.8	5
Vinyl chloride	56.9	62.5	55.7	55.8	−9
***m*- and *p*-Xylene**	86.6	77.2	66.0	76.1	12
***o*-Xylene**	16.7	16.1	15.8	16.7	4

a Production of primary petrochemicals by Pemex. b New product. **Source:** Petróleos Mexicanos (Pemex)

DOMESTIC SALES: Some chemicals strong

Thousands of metric tons[a]	1981	1980	1979	1978	Change 1980-81
Acetaldehyde	123.7	100.9	58.1	59.1	23%
Acrylonitrile	74.2	67.9	60.1	51.4	9
Ammonia	1204.8	966.8	885.7	798.9	25
Benzene	13.5	12.6	11.0	10.9	7
Butadiene	69.5	66.1	57.4	52.6	5
Cyclohexane	52.6	52.8	52.0	42.5	0
Dodecylbenzene	92.5	90.1	83.8	74.1	3
Ethylene oxide	77.9	70.5	56.6	60.7	10
Hexane	51.0	46.1	38.9	36.3	11
Isopropyl alcohol	31.3	27.8	21.4	19.0	13
Methanol	125.2	97.8	84.4	70.1	28
Perchloroethane	15.3	13.5	14.6	10.9	13
Polyethylene, high density	97.8	79.5	63.1	0	23
Polyethylene, low density	257.5	224.3	170.4	144.7	15
Styrene	116.9	101.2	99.2	74.6	16
Sulfur	427.5	408.0	243.2	133.9	5
Toluene	88.4	81.3	76.9	65.4	9
Vinyl chloride	144.7	148.1	119.8	102.2	−2
***o*-Xylene**	27.0	30.7	28.4	21.6	−12
***p*-Xylene**	186.8	116.4	96.7	87.2	60

a Domestic sales by Pemex of primary petrochemicals. **Source:** Petróleos Mexicanos (Pemex)

CHEMICAL IMPORTS: Still rising for several

Thousands of metric tons[a]	1981	1980	1979	1978	Change 1980-81
Acetaldehyde	5.9	58.2	10.2	16.7	−90%
Acrylonitrile	19.7	8.6	43.0	33.6	129
Benzene	21.0	14.5	19.9	13.8	45
Butadiene	55.0	54.8	34.4	39.7	0
Cyclohexane	7.9	10.1	20.3	11.9	−22
Dichloroethane	1.7	14.3	9.0	14.7	−88
Dodecylbenzene	32.8	41.3	31.5	15.3	−21
Ethylbenzene	10.8	10.0	13.4	10.2	8
Ethylene	15.1	0	0	0	—
Ethylene oxide	31.1	34.4	25.3	35.3	−10
Isopropyl alcohol	15.1	18.0	21.7	21.4	−16
Perchloroethylene	16.7	5.5	15.1	12.9	204
Polyethylene, high density	10.2	26.0	5.8	38.3	−61
Polyethylene, low density	125.9	104.0	35.9		21
Propylene	24.3	20.3	0.2	0.6	20
Propylene tetramer	23.1	14.5	15.6	18.5	59
Styrene	87.8	76.7	72.7	36.5	14
Toluene	22.8	36.7	40.7	24.2	−38
Vinyl chloride	84.3	88.8	62.8	56.9	−5
***o*-Xylene**	12.1	13.3	9.6	11.6	−9
***p*-Xylene**	148.0	94.5	82.3	42.9	57

a Imports by Pemex of primary petrochemicals. **Source:** Petróleos Mexicanos (Pemex)

BRAZIL

CHEMICAL EXPORTS: Plastics begin to move

Thousands of metric tons	1980	1979	1978	1977
Acetone	3.4	0.2	0.2	0.4
Acrylonitrile	20.0	0	0	0
Dimethyl terephthalate	9.5	10.7	5.7	0
Perchloroethylene	11.2	4.4	1.9	0
o-Xylene	23.2	3.5	0	0
Sodium hydroxide	24.1	38.0	17.2	3.2
Sulfuric acid	[illegible]	15.8	0.2	0.4
Polyethylene, high density	9.5	1.9	0	0
Polyethylene, low density	8.9	5.5	6.4	3.7
Polypropylene	11.0	7.5	0.1	0
Polystyrene	5.4	3.9	2.5	1.4
Polyvinyl chloride	3.1	0	0	0.1

Source: Associacao Brasileira da Industria Quimica e de Produtos Derivados (Abiquim)

CHEMICAL IMPORTS: Plastics decline

Thousands of metric tons	1980	1979	1978	1977
Benzene	26.7	20.0	1.0	0
Butadiene	31.6	30.0	58.0	46.7
Caprolactam	17.8	13.0	11.9	30.9
Styrene	8.0	5.5	9.5	49.4
Urea	578.9	504.8	399.1	429.9
Vinyl chloride	86.7	78.3	67.3	55.5
p-Xylene	28.5	33.7	61.9	36.5
Ammonia	234.9	172.2	228.5	220.0
Ammonium sulfate	832.3	870.3	771.9	789.6
Phosphoric acid	1470.4	1094.8	1048.5	919.3
Sodium carbonate	203.4	200.7	183.7	143.7
Sodium hydroxide	12.0	18.8	40.0	173.3
Polyethylene, high density	4.4	17.8	24.0	20.3
Polyethylene, low density	32.3	11.0	31.8	30.5
Polypropylene	1.7	3.5	40.9	34.5
Polyvinyl chloride	26.1	99.2	61.2	52.1

Source: Associacao Brasileira da Industria Quimica e de Produtos Derivados (Abiquim)

PRODUCTION: Sharp gains in past few years

Thousands of metric tons	1980	1979	1978	1977	Change 1979-80
ORGANIC CHEMICALS					
Benzene	308.5	259.3	171.7	144.9	19%
Butadiene	134.1	131.8	81.1	80.5	2
Cumene	124.3	98.8	98.3	97.5	26
Dichloroethane	137.9	47.6	0	0	190
Ethylene	715.5	631.2	398.8	362.2	13
Ethylene oxide	112.2	87.2	36.6	30.9	29
Formaldehyde	185.9	138.1	118.4	114.8	35
Methanol	126.6	107.2	95.2	81.3	18
Phenol	87.1	68.8	70.1	71.2	27
Propylene	418.1	376.6	237.8	232.5	11
Styrene	193.5	197.8	145.4	64.1	−3
Toluene	103.6	82.0	72.2	67.5	26
Urea	273.1	151.9	113.4	78.0	80
Vinyl chloride	259.2	133.1	106.5	107.9	95
o-Xylene	75.9	66.5	33.2	28.7	11
p-Xylene	57.9	50.1	0	0	16
INORGANIC CHEMICALS					
Ammonia	443.7	338.9	258.8	184.0	31%
Ammonium sulfate	163.7	89.1	59.1	40.2	84
Chlorine	628.3	587.1	536.4	313.2	7
Hydrochloric acid	108.2	153.5	178.6	159.9	−30
Nitric acid	380.6	345.9	352.5	340.8	10
Phosphoric acid	328.4	200.6	179.6	180.9	64
Sodium carbonate	175.7	118.7	120.7	141.0	48
Sodium hydroxide	691.4	645.1	576.9	316.7	7
Sulfuric acid	2408.2	1910.3	1595.7	1556.3	26
PLASTICS					
Polyethylene, high density	128.7	119.1	52.9	53.6	8%
Polyethylene, low density	307.4	290.3	218.5	199.5	6
Polypropylene	120.9	98.3	24.5	0	23
Polystyrene	124.5	132.7	95.8	85.4	−6
Polyvinyl chloride	340.8	210.7	172.9	160.2	62

Source: Associacao Brasileira da Industria Quimica e de Produtos Derivados (Abiquim)

VENEZUELA

PRODUCTION: Basic chemicals grow fast . . .

Thousands of metric tons	1981	1980	1979	1978	Change 1980-81
Ethylene and propylene	119.9	110.5	11.7	0	9%
Chlorine and caustic soda	46.2	40.4	14.2	14.3	14
Industrial acids[a]	91.5	130.3	152.9	85.1	−30
Ammonia	504.2	438.5	331.4	270.8	15
Urea	315.9	276.5	220.8	135.0	14
Fertilizers	167.7	164.2	63.1	60.9	2

a Sulfuric, hydrochloric, and nitric acids. **Source:** Petroquimica de Venezuela (Pequiven)

CHEMICAL EXPORTS: Nitrogen fertilizers big

Thousands of metric tons[a]	1981	1980	1979	1978	Change 1980-81
Ammonia	205.5	147.4	137.6	160.7	39%
Urea	244.1	160.9	151.7	19.9	52
Ethylene[b]	23.2	23.4	0	0	−1

a Exports by Pequiven of primary petrochemicals only. b Includes small amount of propylene.
Source: Petroquimica de Venezuela (Pequiven)

. . . and downstream products are catching on

Thousands of metric tons	1981	1980	1979	1978	Change 1980-81
Aluminum sulfate	34.3	23.5	22.3	24.5	46%
Chlorofluoromethanes	7.1	8.0	5.7	5.8	−11
Dodecylbenzene	22.6	31.1	26.1	20.7	−27
Phthalic anhydride	18.0	13.4	12.3	13.4	34
Polyethylene, low density	52.7	40.7	33.5	43.0	29
Polystyrene	30.5	32.3	25.2	21.5	−6
Polyvinyl chloride	23.2	17.2	4.8	4.5	35
Propylene tetramer	13.8	11.6	0	0	19
Sodium tripolyphosphate	36.8	35.1	31.9	20.3	5

Source: Petroquimica de Venezuela (Pequiven)

West Germany's ACHEMA is barometer of new chemical technology Page 26

Chemical & Engineering NEWS

June 21, 1982

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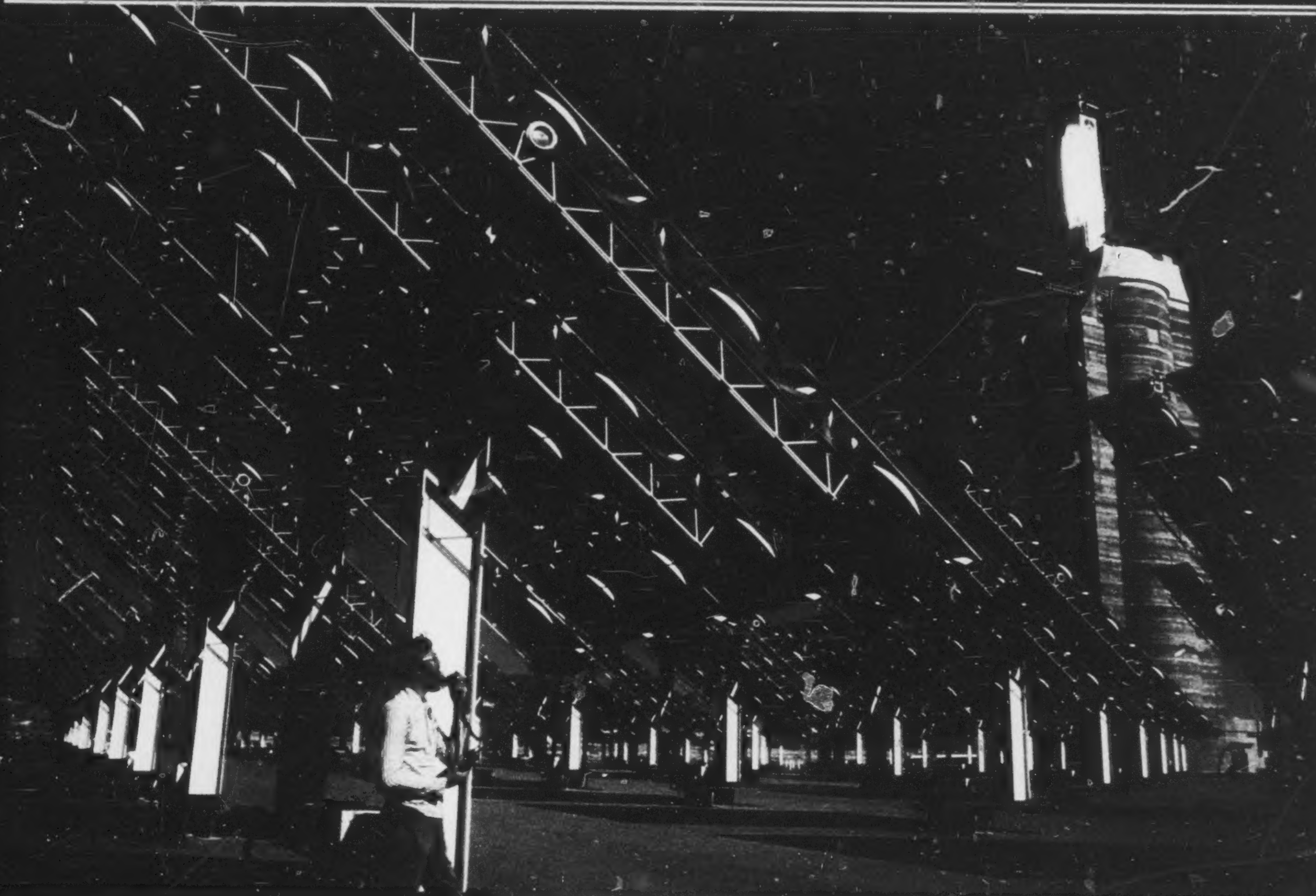

NEW ENERGY SOURCES

Long-term research gains priority

Page 7

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Chemical & Engineering NEWS

Cover: Sandia Laboratories' central receiver test facility near Albuquerque, N.M., which Sandia calls the world's largest solar testing facility

2 Letters
3 Editor's Page

Concentrates
15 Business
21 Government
23 Science/Technology

The Departments
33 People
35 Meetings
52 Newscripts

News of the Week

- ***Dietary guidelines to reduce the risk of cancer,*** *prepared by National Research Council committee, draw criticism from meat industry, research groups.* **Page 4**
- ***Capital spending plans*** *of U.S. chemical and allied products industries cut more than $1 billion from earlier figures.* **Page 5**
- ***Justice Department issues new merger guidelines*** *to help businesses determine likelihood of antitrust suits.* **Page 5**
- ***Conservation Foundation*** *scores Reagan Administration for lack of environmental policy, research cutbacks.* **Page 5**
- ***General Motors foundation awards prizes*** *to two U.S. biochemists and a British surgeon for contributions to prevention, treatment, and science of cancer.* **Page 6**
- ***Manufacturers would have to supply data*** *on production, use, and exposure of 300 chemicals under EPA proposal.* **Page 6**

News Focus

- ***Energy research and development*** *is being re-examined, calling for new efforts in basic research to provide technological advances needed to assure future supplies.* **Page 7**

Business

- ***Plastics monomers are having another bad year;*** *prices are down and profits very slim for styrene, vinyl chloride, and toluene diisocyanate.* **Page 16**

International

- ***Japan strives for the competitive edge*** *by proposing to reduce its ethylene capacity and establish a joint-management concept for remaining ethylene units.* **Page 20**

Government

- ***Separate acid rain review panels*** *set up by U.S. and Canada, on U.S. insistence, will scrutinize the results of joint scientific working groups.* **Page 22**

Science

- ***Lasers are being used*** *by scientists to excite selected vibrational modes in simple molecules, resulting in specific molecular changes.* **Page 24**
- ***Device for detecting magnetic fields,*** *developed at Berkeley lab, operates at quantum limit of sensitivity.* **Page 25**

Technology

- ***Achema '82 charts the wave of the future;*** *evolving chemical technologies focus on alternative feedstocks, pollution control, and energy consumption.* **Page 26**

Books

- ***"The Cookbook Decoder, or Culinary Alchemy Explained"*** *by Arthur E. Grosser tells what every chemist should know about cooking but was afraid to ask.* **Page 31**

Plastics monomers face third depressed year

Lower volumes and selling prices in 1982 for styrene, vinyl chloride, and toluene diisocyanate put severe profit squeeze on producers

Bruce F. Greek
C&EN, Houston

After 1981, could 1982 be any worse for plastics monomers such as the three major ones in the following pages—styrene, vinyl chloride, and toluene diisocyanate (TDI)? So far, the answer is yes. The prospects are for lower production in each, possibly lower average real selling prices, and little or no profit.

The problems faced by makers of these monomers reflect those of their users—lower demand and excess capacity in a long, stop-and-go recession. Forecasters seem to have given up predicting when demand will get back to its historic highs of 1979. Future demand for these monomers surely will take longer to regain those highs than all but the most pessimistic have thought.

Pessimism seems to pervade producers of these monomers just as it does most other major-volume organic chemicals. In fact, producers are hunkering down just trying to survive. Capacity expansions have been minimized, and substantial in-place capacity is shut down. Other efforts to economize take precedence under pressure of a cost-price squeeze, which led to large declines in net income for most chemical companies in 1981 and so far this year.

The economic slide can be seen clearly from the decline in commercial value of these monomers in 1982 from 1981. Because it has the largest volume of these three monomers, styrene could have the largest drop in value in 1982, possibly some $750 million or 25% from 1981. Vinyl chloride could be down more than 20%, or $300 million, in value this year. TDI's value will be off minimally, mainly because its production volume change is small. As a group, the three would have a total of some $3.6 billion in 1982, down 30% from 1981 and down about 10% from forecasts for 1982 made last year.

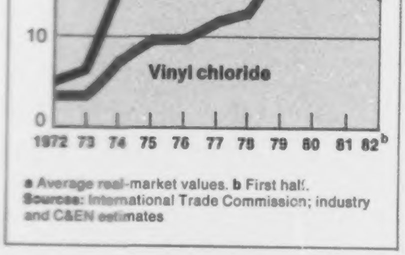
When the year's sales are totaled, the real commercial value could be a lot lower than expected because of recent and current discounting of list or posted prices. Some of these discounts take the form of formal "temporary voluntary allowances." Others may be sudden concessions to gain a sale. These discounted prices, if not increased during the rest of 1982, could pull down the total value another 10% for the year.

Key Chemicals

For example, during the second quarter most U.S. styrene sales were at prices 20 to 25% below list. Export sales were off another 10%. If a sixth of production of styrene is exported at a third off list price, and the rest valued at a fifth off for the year, the total value of production would be a bit over $1.8 billion in contrast to about $2.5 billion at list prices. Presumably, discounting will be reduced during the second half of 1982 as demand for styrene firms a bit.

Similar analyses can be made for vinyl chloride and TDI. In vinyl chloride's case, the discounting is formalized as temporary voluntary allowances. Both of these monomers sell at discounts of 20 to 25%.

Major monomers' prices have sunk in the recession



a Average real-market values. b First half.
Sources: International Trade Commission; industry and C&EN estimates

In short, the value explosion in the 1970s, which gave these monomers some very good business years, is long gone. About the only remaining evidence of those heady days is the string of unneeded new plants resulting from visions in better times.

It was good while it lasted. Styrene's average merchant value per pound increased fivefold, from 6 cents to 30 cents, between 1972 and 1980, according to the International Trade Commission. And 30 cents is about where it remains today. Vinyl chloride's merchant value shot up almost as much, from 4 cents in 1972 to a peak of 19 cents in 1979. Since then, vinyl chloride's average value has eroded to about 15 cents.

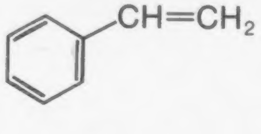
Not that producers haven't tried to push up prices. Styrene's list prices are 7.5 to 10 cents higher than the going rate, and vinyl chloride's posting is 7 cents higher.

Obviously, the question arises whether list prices are meaningful at all. A strong case for list prices can be made if all production costs are counted plus enough return on investment to justify new investment. Discounting has taken away the return and maybe some coverage of real production costs. Hence comes low profitability and the lack of capacity expansion.

Longer term, industry analysts feel that the seed corn is being eaten, so to speak. Capital expansion money will not be generated for capacity that will be needed in the mid-1980s and later. Prices then could go up and exports could decline. Imports, spurred by higher prices and capacity built in other countries, could surge in the latter part of this decade. But then prices could decline, and the U.S. industry would be no better off.

The monomers industry might even be worse off if it has to cut capacity. Investment money would then flow to other uses, away from low-valued commodity chemicals such as these that are several steps from more specialized consumer products.

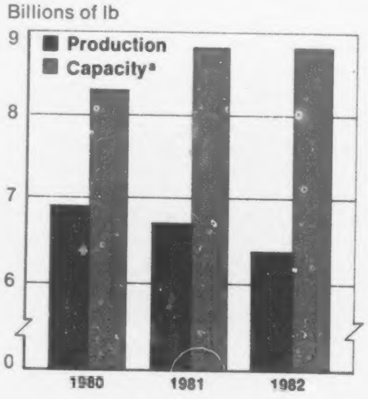
Key Chemicals



Styrene

- ***Demand down***
- ***Capacity flat***
- ***Prices discounted***

PRODUCTION/CAPACITY



[a] First quarter.

HOW MADE

Dehydrogenation of ethylbenzene obtained from ethylene and benzene or from petroleum reformate; coproduction with propylene oxide

MAJOR DERIVATIVES (U.S.)

Plastics-oriented polymers 80%, styrene-butadiene rubber 10%

MAJOR END USE (U.S.)

Fabricated plastics 90%

FOREIGN TRADE

Exports—easing to about 1 billion lb in 1982, imports—small

PRICES

List prices 37.5 to 40 cents a lb; discounting heavy, to 30 cents

COMMERCIAL VALUE

$2 billion for production, 1982

By the relative standards of this deep recession year, U.S. producers of styrene actually are better off than producers of many other organic chemicals. This despite a large amount of plant capacity temporarily shut down and severe discounting in selling prices.

Still, for 1982 a consensus puts styrene production at less than 6.5 billion lb. It could be as low as 6.2 billion lb. There are no optimists around who will even forecast a match of 1981 production of about 6.7 billion lb, which was itself down 3% from 6.9 billion lb in 1980.

If 1982 production reaches 6.5 billion lb, existing nameplate capacity for styrene would have run at an average rate of 74% for the year. That rate likely would be one of the higher ones in organic chemicals this year.

Admittedly, first-quarter production of styrene ran about 5.5 billion lb at an annualized rate, according to preliminary data from the International Trade Commission. In contrast, last year's annualized first-quarter rate was very close to the total reported for the year of 6.7 billion lb. Later in 1981, monthly production went up and then faltered in the fall and winter very much as did other organic chemicals.

A similar pattern of an upswing in styrene production this spring may have occurred even though considerable capacity is shut down. Currently, demand for styrene exceeds production, according to some in the industry. In other words, the inventory trimming begun in 1981 is continuing. Estimates of the remaining inventory and its direction vary from one analyst to another.

All inventory estimates hinge on the world economic outlook for the second half of 1982. If consumer demand improves significantly in the second half, then styrene production will have to increase rapidly to meet demand and rebuild inventories. One view is that a demand increase in durables markets, especially autos, would help styrene inventories more than an increase in demand in nondurables, mainly packaging uses.

Styrene exports for 1982 are expected to be about 1 billion lb, down a little from more than 1.1 billion lb in 1981. Analysts believe that inventory liquidation has gone disproportionately into exports. However, exports still could spurt 10 or 20% in 1982 because of low production of competing aromatics in Europe, where a lot of steam-cracking olefins capacity with aromatics coproducts has been shut down.

Neither such a business recovery nor a plateau followed by another downturn will have much effect on styrene's use patterns in the next year or so. Polymers, dominated by polystyrene, take almost all of styrene production. These polymers tend to gain volume slowly at the expense of other materials, especially in packaging. Here, expandable polystyrene seems to be most promising and accounts for much of the small expansion in polymerization facilities. Even so, after 1982, combined demand growth rates for styrene polymers may average only half or less that of their 5% annual rate of the 1970s.

Of the other polymers containing styrene, none are expected to change enough in volume to affect total styrene production. Styrene-butadiene-rubber (SBR) output, for example, could turn up significantly this fall if auto production rises. Although rubber production is languishing amid rumors of more SBR plant shutdowns, inventories of finished rubber appear low. To some analysts, this suggests a possible rush for styrene if tire demand rises suddenly. Even so, such a flurry wouldn't do much to help the overall styrene picture, since rubber accounts for just 10% of demand.

With no big new uses coming and reduced growth rates forecast for existing uses, styrene producers are taking a very conservative view toward plant expansion. Discounting in selling prices, somewhat offset by lower feedstock costs, also makes expansion very difficult to justify. So, other than debottlenecking and efficiency improvements, which usually add capacity, no expansion of styrene capacity will occur this year.

With a likely decline in styrene production in 1982 and no capacity expansion, producers will have to put 1982 down as a standstill. At best, efficiency efforts and shutdowns of excess capacity may let them make a little money.

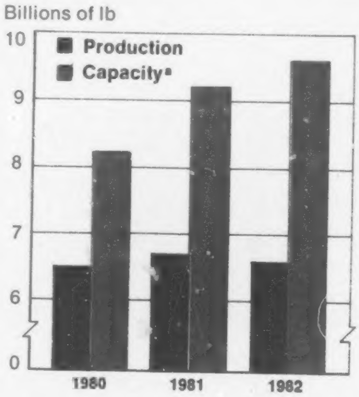
Key Chemicals

Vinyl chloride

$CH_2{=}CHCl$

- ***Demand low***
- ***Capacity growth slowing***
- ***Prices forced down***

PRODUCTION/CAPACITY



a First quarter.

HOW MADE

Dehydrochlorination of ethylene dichloride made by reacting ethylene and chlorine

MAJOR DERIVATIVES (U.S.)

Vinyl polymers nearly 100%

MAJOR END USES (U.S.)

Fabricated vinyl plastic items nearly 100%

FOREIGN TRADE

Exports—may fall again to 700 million lb in 1982, imports—rising a bit to possibly 100 million lb in 1982

PRICES

List price 22 cents a lb with a 6-cent official discount

COMMERCIAL VALUE

$1.1 billion for production, 1982

As summer arrives and demand jumps for consumer vinyl products such as garden hose and beach toys, producers of the monomer, vinyl chloride, have achieved a price increase from around 14 cents a lb to 16 cents. But that still leaves tabs discounted far below the list price of 22 cents. Although producers really don't expect to sell more monomer this year, this price increase should be considered a real achievement if it lasts, for 1982 will go down as one of the poorest years ever for vinyl chloride.

Just how poor becomes clear from estimates of plant operating rates. If production comes close to matching 1981, say between 6.5 billion and 6.7 billion lb, then the available nameplate capacity will have run at less than 70% for the year.

To match 1981 production, 1982 will need a much better second half than the sorry clip of the first six months. Preliminary estimates of first-quarter production show an annualized rate of about 5.2 billion lb. Hence, the first-quarter operating rate was a horrendous 54% of the 9.6 billion lb of nameplate capacity. Obviously, considerable capacity was shut down. Although some shutdowns have been stretched out, production apparently improved in April and May, according to industry sources.

As with most other large-volume organic chemicals, production of vinyl chloride has picked up to more nearly reflect demand than it did in the fourth quarter of 1981 and the first quarter of 1982. Inventory liquidation pretty well has ended for the simple reason that inventories reached almost the minimum level needed to sustain smooth shipments.

For vinyl chloride, the more critical inventory is in its precursor, ethylene dichloride, since even in the best of times, inventories of vinyl chloride itself are kept very low. In 1981, part of the inventory problem was that raw-material chlorine producers, many of them also vinyl chloride and polyvinyl chloride producers, hunted for ways to get rid of it so they could sell more coproduct caustic soda, then in much stronger demand. The way out last summer was to build inventory of ethylene dichloride.

Sopping up that inventory during the winter badly hurt production of ethylene dichloride. Instead of using chlorine directly, vinyl chloride producers either hit their ethylene dichloride inventory or bought merchant ethylene chloride, cracked it, and used the coproduct hydrogen chloride via oxychlorination.

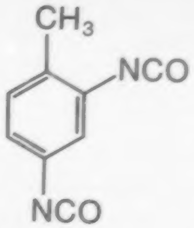
Now demand for caustic has weakened along with caustic's selling prices. And no longer is chlorine valued at practically nothing in the total picture of caustic-chlorine production. In effect, less low-cost chlorine along with interest costs that are still relatively high makes carrying a big inventory of ethylene dichloride less likely than a year ago. This trend seems to be one that will continue through the rest of 1982.

Although accounting schemes have a lot to do with determining costs and profit in vinyl chloride, higher chlorine costs and probable increases in raw-material ethylene costs this summer make the recent price increases for vinyl chloride necessary if producers expect to stay in business. Up to now, ethylene prices, which declined largely to about 18 cents a lb with some as low as 17 to 17.5 cents, certainly helped vinyl chloride producers make it through the winter, when vinyl chloride touched bottom at 14 cents a lb or less.

But about all that can be said for the present profit situation is that the near-term outlook is break-even. The large overcapacity in vinyl chloride plants will keep downward pressure on prices for a long time. Until the economy improves, none of the many uses of polyvinyl chloride will gain volume significantly. The big construction outlets, such as in pipe and fittings, might turn up a bit before the overall construction market does, but this alone will not be enough this far into the year to do much for overall monomer production.

A continuing slide in vinyl chloride exports, coupled with modest increases in imports, means that the U.S. market will in effect have to consume more of total production. This will be one more damper on vinyl chloride output in a year when producers scarcely need it.

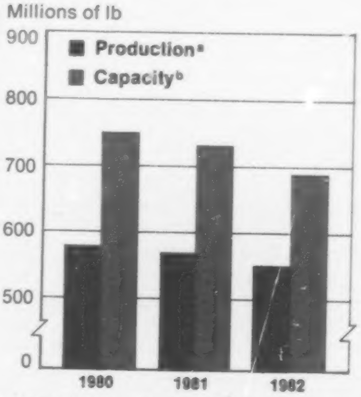
Key Chemicals



Toluene diisocyanate

- ***Demand slipping***
- ***Capacity cut back***
- ***Prices soft***

PRODUCTION/CAPACITY



a Mainly 80/20% mixtures of 2,4- and 2,6-isomers, but includes some 65/35% mixtures.
b First quarter.

HOW MADE

Nitration of toluene, followed by reduction to diamine, reaction with phosgene, purification, and recovery of coproduct hydrochloric acid

MAJOR DERIVATIVES (U.S.)

Polyurethanes almost 100%

MAJOR END USES (U.S.)

Flexible polyurethane foams 90%, polyurethane coatings 5%

FOREIGN TRADE

Exports—falling under 150 million lb in 1982, imports—negligible

PRICES

List price 93 cents a lb, some discounting

COMMERCIAL VALUE

$500 million for production, 1982

U.S. producers of toluene diisocyanate (TDI) would like to think that their production is pulling out of a severe slump from late 1981. Some feel that TDI might exceed 1981 production of 570 million lb. Others think 1982 production will be off a bit to about 540 million to 550 million lb.

Of course, all opinions are prefaced on the outlook for TDI's big markets in housing—both new construction and sales of existing houses—and in autos. It will be the second half that tells the tale for the year. In the first quarter, TDI production was down about 6% from first-quarter 1981. Such a decline for a large-volume organic chemical with a relatively high selling price must be considered as doing fairly well during the current severe recession.

This is not to say that TDI doesn't have problems. If production does decline for all of 1982, it will mark the third year in a row on a gentle downward slope. During this time, selling prices haven't done much more than barely cover costs. Sometimes prices couldn't even do that.

The result of declining production and little, if any, profit has been no plant capacity expansion since 1980, when BASF Wyandotte did a large debottlenecking project.

In fact, total capacity has declined. Early in 1980, Du Pont completed its exit from the business. Then in the fourth quarter of 1981, Olin closed its 40 million lb-per-year plant in Ashtabula, Ohio.

Estimates vary on nameplate capacity for TDI and even more as to actual operable capacity, because corrosion and other problems have been notorious in limiting output. Assuming that nameplate capacity as 1982 opened was about 690 million lb per year and that production declines for the year to 550 million lb, the plant operating rate for TDI will average 80% for the year. This rate, according to some industry sources, will be not too far below the maximum effective rate, which they put between 85 and 90% over a year.

Even with this relatively small surplus capacity, it might take time for demand to use it up. In several market areas, the outlook for TDI seems poor. The basic weak spots are exports and durable goods, compounded by competition from other isocyanates.

Export problems are similar to those of many other organic chemicals—higher U.S. production costs and competition for sales by foreign producers either in their own countries or in other consuming countries. Exports probably will tend to decline, influenced by the world economy. The result will be more TDI produced in the U.S. that will have to be absorbed by the U.S. market.

The durable goods market problem downstream for polyurethanes and, in turn, for TDI stems directly from the energy crisis of the past decade. In the auto industry, fewer, smaller cars have cut deeply into polyurethane demand. At first, polyurethanes—often in composites containing TDI, methylene diisocyanate (MDI), and polymeric MDI—seemed to penetrate more seating and other uses and hence to continue to grow in demand. But as the down-sizing in autos increased, less total polyurethanes were being used per car. Most forecasters hold that any fresh gains in use of polyurethanes per car will be small for the next few years, especially if economics force changes in models to be made less often.

Furniture is still the dominant use of flexible polyurethane foams, where most TDI goes. The share of flexible foam in furniture has slipped as recent recessions have reduced demand, especially demand related to purchases of houses. Again, prospects for much of a new demand increase seem some time off.

Even if these uses do increase, TDI may lose out slowly to its competitor, MDI. In both monomeric and polymeric forms, MDI production has been growing faster than has TDI. The reason is lower cost. Consumers of polyurethanes have found that MDI can be used to make foam which has properties as acceptable as a TDI-based foam and at a lower cost.

Longer-term growth rates for TDI may settle at 2 to 3% annually, whereas rates for MDI might be 7 to 10% annually. The result probably will be a continuation of the long pause in new TDI plants.

Japan proposes reducing its ethylene capacity

To make its petrochemical industry more competitive, Japanese ministry wants to establish joint management of reduced ethylene capacity

In Japan, they are called "structurally depressed industries." These industries have been trying to regain some of the international competitiveness—and respectable profits—that they have been losing ever since the world's first oil crisis of 1973–74 saddled them with high energy and raw material costs.

Some of them haven't made it yet. Japan's petrochemical industry is one of them.

Now, the powerful Ministry of International Trade & Industry (MITI) has come up with a scheme that it hopes will give the petrochemical industry a little more competitive muscle. Its recommendation: Reduce Japan's ethylene capacity a substantial 30% and establish a joint-management concept for the surviving ethylene units.

Not all of Japan's petrochemical industry leaders subscribe to MITI's joint-management idea. But none can argue with the reasoning that led to the recommendations from the ministry.

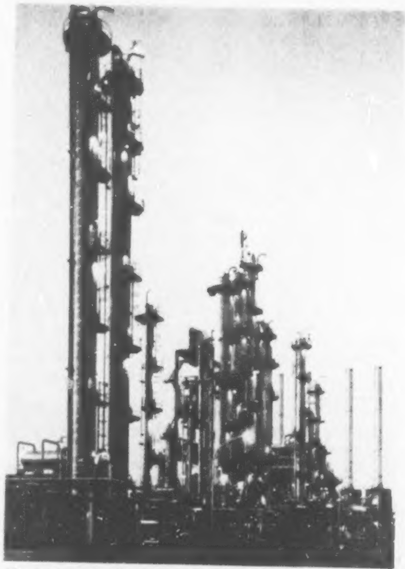
Buffeted by weak demand in Japanese markets, a flood of imported ethylene derivatives, and declining export opportunities, Japan's ethylene producers have been taking a beating.

Japan's nameplate ethylene capacity is about 6.2 million metric tons per year. By closing some plants, either permanently or temporarily, the industry has brought this capacity down to 5.4 million metric tons.

Still, this hasn't been enough. Ethylene output peaked in Japan in 1979, when production hit almost 4.8 million metric tons. In 1980, it dropped to 4.2 million metric tons and, last year, it slipped further to 3.6 million metric tons.

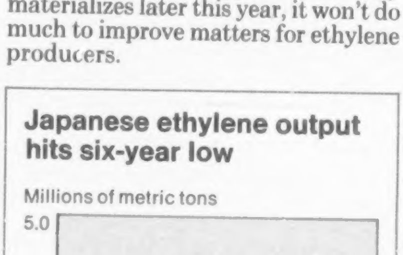
Results for the first quarter of 1982 offer little encouragement. Ethylene output during the first three months was only 860,000 metric tons. That's just 3.4 million metric tons on an annual basis.

The ethylene industry's plant operating rates have plummeted from 78.7% of capacity in 1979 to 56.9% early this year. Even if the hoped-for upturn in the Japanese economy materializes later this year, it won't do much to improve matters for ethylene producers.



Sumitomo Chemical's ethylene plant at Chiba could be a merger candidate

Japanese ethylene output hits six-year low



Source: Ministry of International Trade & Industry

MITI believes that Japanese producers will continue to face increasing import pressures throughout the eighties. It sees Japan's ethylene output bouncing back to no more than 3.8 million metric tons by 1985 and leveling off at about 4 million metric tons through 1990.

As a result, MITI wants to see the country's ethylene capacity cut to about 4.5 million metric tons per year. It suggests scrapping the older, smaller, inefficient naphtha crackers first.

There are plenty of candidates. The average age of Japan's ethylene units is almost 12 years. More than half of them have a capacity of 200,000 metric tons per year or less. More than one third of them have capacities of less than 100,000 metric tons.

Some of these units already have been shuttered, but there's still a long way to go to reach MITI's 4.5 million ton target.

Under the MITI proposal, the 15 petrochemical centers at which ethylene is produced would be reduced to six or seven. At several of the sites, two or more companies would be expected to consolidate their operations.

Although most industry leaders agree that something has to be done, not all of them think that the something has to be so drastic as MITI's proposed joint-management concept. Some feel that a cooperative marketing system would be a better way to go.

Others favor extending the Law on Extraordinary Measures for Specific Depressed Industries. This law, popularly known as the Structural Recession Law, expires in June 1983. Designed to help troubled basic industries such as aluminum, pulp and paper, and petrochemicals, it permits industries to cut capacity and rationalize output without worrying about the Antimonopoly Act.

MITI is studying the possibility of extending the Structural Recession Law or replacing it with a new one. It also is considering other alternatives to help the petrochemical industry. But a much lower ethylene capacity is the cornerstone of any plan for the industry's survival.

Earl Anderson, New York

Chemical &
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NEWS

PRELIMINARY PROGRAM
CS Kansas City meeting Page 55

CALENDAR OF EVENTS
Scientific meetings Page 67

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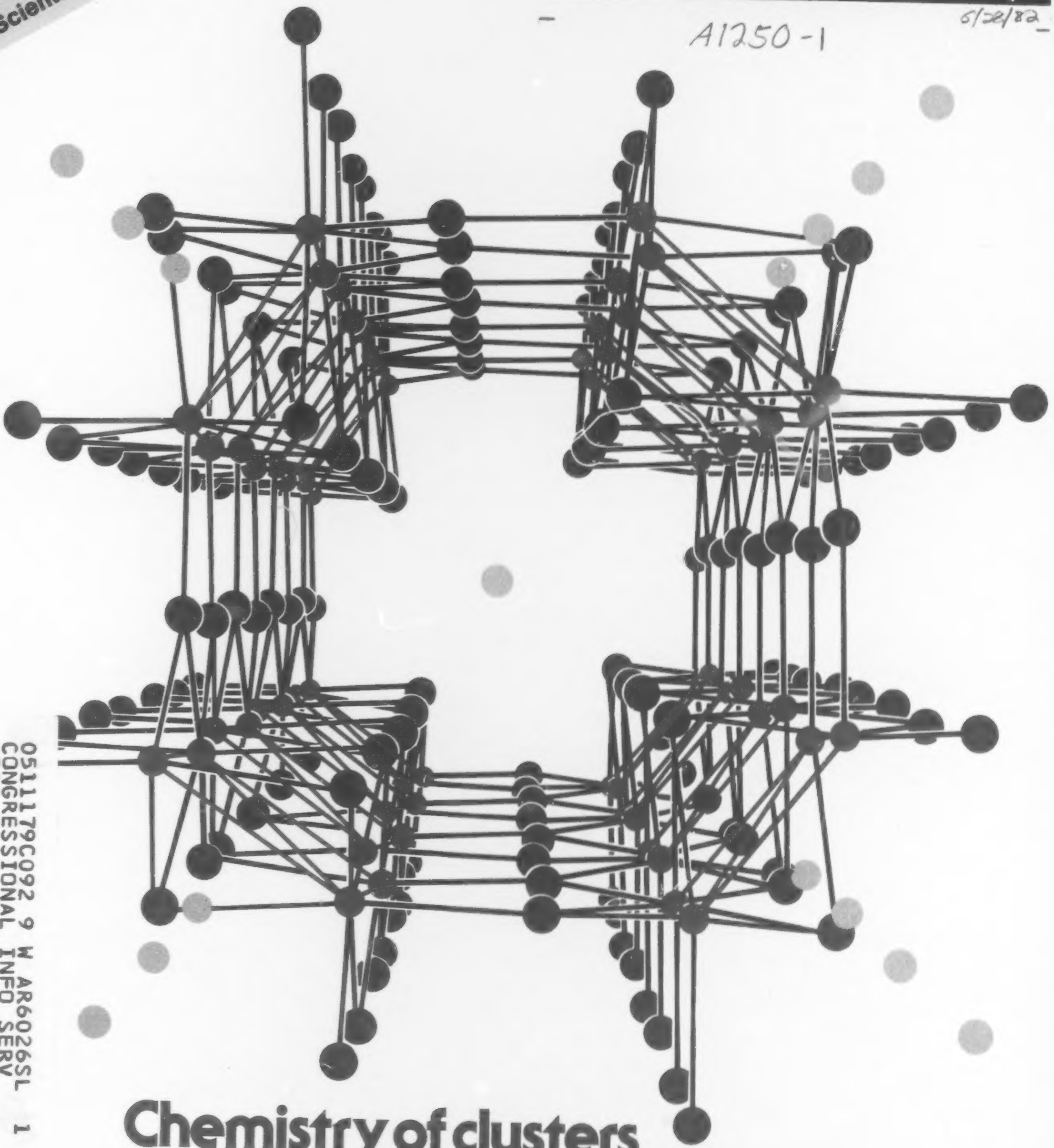

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Chemistry of clusters with metal-metal bonds

Page 40

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Chemical & Engineering NEWS

Cover: Metal cluster $Ba_{1.13}Mo_8O_{16}$, characterized by Robert E. McCarley of Iowa State University, Ames, forms an infinite array. Oxygen atoms are shown as blue, molybdenum as magenta, and berium as green

4 Letters
5 Editor's Page

Concentrates

13 Business
19 Government
25 Science/Technology

The Departments

49 New Products
84 Newscripts

News of the Week

- ***Proposed Gulf Oil/Cities Service merger*** *would create one of largest U.S. companies, affect polyethylene market.* ***Page 6***
- ***National Plastics Exposition,*** *mirroring current business climate, has slow start but gains momentum.* ***Page 7***
- ***Performance standard for burning hazardous wastes*** *in incinerators set by EPA ignores most industry objections.* ***Page 7***
- ***Proposed amendment*** *to recombinant DNA research guidelines would prohibit cloning to develop biological weapons.* ***Page 8***
- ***Canadian report claims*** *that results of yellow rain attacks in Southeast Asia not explained by natural mechanisms.* ***Page 8***

Business

- ***PPG changes course,*** *emphasizes higher-value-added specialties over commodity chemicals for profit recovery.* ***Page 14***
- ***Outlook for ethylene due to improve*** *through the '80s; predictions indicate rising prices and increased plant use.* ***Page 16***

Government

- ***Congress holds 1983 budget to 1982 levels,*** *freezing funding for R&D and negating work by authorizing committees.* ***Page 20***
- ***U.S.S.R.'s proposed ban on chemical weapons*** *presented to UN; plan calls for multilateral disarmament.* ***Page 22***

Science

- ***NRC report on diet/cancer link*** *shows dangers of formulating public policy guidelines from incomplete research data.* ***Page 26***
- ***Nutritional disorders*** *obesity and anorexia nervosa associated with significant changes in the body's hormonal balance.* ***Page 28***
- ***Structure of carzinophilin A,*** *a potent antitumor agent, determined by chemists at University of Alberta.* ***Page 30***

Technology

- ***Progress in C_1 chemistry,*** *including catalysts and methanol processes, discussed at international symposium.* ***Page 31***

Special Report

Studies of bonds between metal atoms *reveal superconductors, organic-reaction catalysts, and photosensitive complexes that may play a role in solar energy.* ***Page 40***

Preliminary Program

- ***Early details of the ACS annual meeting*** *to be held in Kansas City in September include preregistration coupon.* ***Page 55***

Meetings

- ***C&EN updates its calendar of events*** *of scientific interest.* ***Page 67***

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Letters

Scientific manpower shortage

SIR: The irony of your juxtaposition of two mutually contradictory reports on the scientific manpower shortage (C&EN, May 17, pages 28 and 29) was not lost on your readers. The articles entitled "Improved science, math education urged" and "Demand wanes for new chemical engineers" illustrates perfectly how the bureaucracy can get 180° out of phase with the national scene. What fodder for the Libertarian Party!

Arthur Bradley
Floral Park, N.Y.

Natural and human resources

SIR: In a technical society such as the U.S., it is the efficiency and creativity with which we use our natural and human resources that determines the quality of our existence. This is a nontechnical way of stating that we must be fully cognizant of both the potentials and limitations of chemical thermodynamics. We seek a future trend for our R&D; it can be derived from the above thesis.

Both the wisdom of Thomas Wolfe's you can never go back and the Second Law point to the vector quality of time's arrow. We must look forward, not back, to an improved quality of life rather than mere increase of the GNP. Hence, it is most distressing that government R&D expenditures seem to be channeled into enterprises which can no longer be classed as having future potential: the nuclear-military complex, the depletion of our irreplaceable resources, and the stimulation of wasteful transportation methods. It is even more alarming that at least one university administrator has supported the first of these activities, apparently to attract government funds. The present anticonservation policy is bad thermodynamics, and hence is bad economics and bad politics.

We must look to new basic knowledge for ways to invest in the future of America. Improved creativity depends on improved scientific communication, and the shifting of the R&D load to industry of a size commensurate to the work at hand. When we create massive conglomerates, we may secure a quick profit, but the reinforced bureaucracy destroys creativity and communication for the long pull. We reduce the quality and the second-law efficiency of the operation. There is a lesson to be learned from the fact that the "second 50" are outperforming the "first 50" (C&EN, May 10, page 21).

It remains to create an economic climate favorable to these newer developments of our science. Reduction of interest rates, reduction of the ratio of federal expenditures to GNP (now nearly 24%), elimination of capital gains taxes (but increase holding time to five years) will all stimulate investment, rather than trading or buying government paper. The "bracket creep" of the excess profits tax should be modified to provide a sliding scale varying logarithmically from 0% at $100,000 to, say, 60% at $1 billion, so that the stagnation and bureaucracy inherent in large size is not further encouraged. The track record of the small to medium-sized technically oriented company in terms of creativity, communication, and efficiency is excellent; let's give them a clear track!

It is to the "middle class" in American technical enterprise that we must look for the future. Their creativity and productivity can restore an economy which is being destroyed by the thermodynamically unsound double-whammy of subsidized waste and a record government deficit.

Winslow H. Hartford
Emeritus Professor, Environmental Science, Belmont Abbey College, Charlotte, N.C.

Favors two annual meetings

SIR: "Is there a need for two ACS national meetings per year?" (Fred Basolo, president-elect, ACS, C&EN, May 17, page 32). Yes, definitely there is a need. The two annual meetings are the cement which hold ACS members of this big country together. Having only one national meeting per year and shifting the emphasis on presentation of papers, meeting with colleagues, renewing contacts, etc., to regional meetings is, in my opinion, the first and unfortunately, rather effective, step toward a fragmented ACS.

I also have difficulties in agreeing with the main reasoning of Basolo for abandoning the second annual meeting, namely saving money. Up to very recently there was the philosophy that money can overcome all problems. Now it seems another and equally simplistic point of view comes into vogue, namely saving is the cure for everything. If we want to preserve the American Chemical Society as *the* society for all chemists and continue to provide a forum for exchange of ideas for staying in contact with the colleagues in the "Far West," "Way Up East," "Down South," in the "Heartland Midwest," or "Up North" keep the two annual national meetings alive.

Hans Zimmer
Professor of Chemistry, University of Cincinnati

Chemical dependence

SIR: I am an ACS member and a chemist of some 20 years standing. I am also, incidentally, a recovered alcoholic and drug addict who would

Continued on page 74

Correction

- June 7, page 17: The profit margin columns in the right-hand portion of the table are labeled in reverse—the first column is 1981, the second 1980.

Ethylene economics due for slow improvement

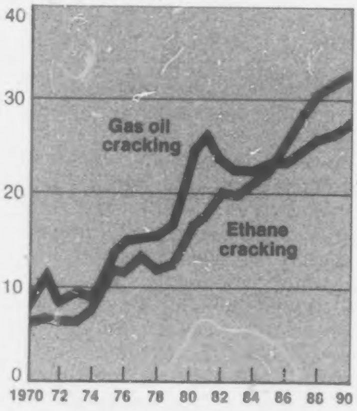
Ethylene, the fulcrum of the organic chemicals business, will follow a course of gradual improvement through the 1980s, according to Stanford Field, consultant to SRI International's Chemical Process Economics Center. Speaking at the Anaheim meeting of the American Institute of Chemical Engineers earlier this month, he said that ethylene prices, although weak through 1983, will rise, but slowly at first. Plant use also will climb slowly, but new plants may not appear until late in the decade.

According to Field, ethylene demand will grow at about 4% per year, a rate greater than the growth rate of gross national product. Ethylene imports, mainly from Canada, will reach 1.5 billion lb per year by 1990, although the U.S. probably will remain a net exporter of ethylene derivatives. Capacity utilization of ethylene plants in the U.S. probably will rise slowly; and new plant construction should not be expected before 1985 and probably sometime late in the decade.

Field bases his ethylene outlook on several key assumptions: for instance, that GNP will grow at a constant-dollar rate of 3% per year through 1990, and that inflation will remain slightly less than 8%. The world's oil supply, one of the two main ethylene sources (the other source is natural gas), will continue to be dominated by the Organization of Petroleum Exporting Countries, he assumes. Field says that oil demand will grow only 1 or 2% per year. This lessening in demand will prompt Saudi Arabia to maintain current-dollar price of light crude at $34 per bbl for the rest of 1982. For 1984 and 1985, Field expects the constant-dollar price of light crude to remain steady and the actual price to increase about 2.5% per year after 1985 and through 1990.

Gas oil will be a cneaper feedstock than ethane

Ethylene production cost, cents per lb (1979)



Source: SRI International

By the end of the decade, the current-dollar price of light crude will be about $70 per bbl, Field predicts, unless there is a prolonged worldwide economic decline. In that case, he says, there might even be a decline in crude prices.

Price margins over costs in the oil business in the 1980s likely will rise owing to more expensive products (such as higher-octane gasoline), higher costs for environmental protection, and higher profits. However, the profitability won't be nearly so good as it was in the 1970s. Field also expects to see the shutdown of a total of 1 million bbl per day of uneconomic refinery capacity in the 1980s because of refiners' adjusting to "structural changes" in oil use.

The price of natural gas, the other main raw material, also is a key element in ethylene economics. Natural gas pricing is a bit chaotic at the moment, and Field notes that the recent oil price rise coupled with decontrol of U.S. crude prices in 1982 has caused an acute disparity between the price of gas and that of oil. Field assumes for his scenario that natural gas prices will be decontrolled more or less on schedule, that is in 1985, despite various attempts to do it sooner.

Much additional confusion in the gas picture derives from the plethora of gas categories—for example, interstate gas, stripper well gas, Prudhoe gas, incentive gas, new gas, and imported gas. New gas was assumed to be the swing material that would balance requirements.

In general, Field believes that most gas prices will rise to the level of imported gas, with Canada being the principal source of imports. The present Canadian oversupply is expected to disappear in the late 1980s, when Canada completes its gas pipeline to the eastern provinces. The imported Canadian gas price will rise to reach parity with low-sulfur residual fuel oil in the U.S. Field predicts that the average rate of natural gas to local distributors will rise from 54% of low-sulfur fuel oil price in 1981 to 93% in 1990.

The ethane raw material fraction of natural gas has been in good supply at low cost because of the federal government's control of old gas prices. The supply of low-cost ethane is not expected to be sufficient, however, to meet demand beyond 1983.

By 1985, Field says, demand for ethane from all sources is expected to exceed supplies. And beyond 1986 it probably will not be profitable to use ethane as a substitute feedstock in naphtha and oil steam crackers, he believes.

By 1986 any large new ethane cracker probably would be the highest-cost source of ethylene and the main factor in determining the price of ethylene, Field says. Not only will no new steam crackers come on stream after 1985, but ethane cracking may no longer show a profit in some cases.

Field admits that ethylene prices will remain weak until the end of 1983, when low-cost ethane runs out. In 1984 and 1985, the price will rise modestly, and thereafter until 1990, price rises will be steeper. □

Ethylene price will accelerate in late 1980s

	1970	1977	1980	1984	1986	1990
Ethylene supply (billions of lb per year)	18.1	25.4	27.8	35.1	36.0	40.7
Production	18.1	25.4	27.8	34.8	35.4	39.2
Derivative imports	—	—	—	0.3	0.6	1.5
Ethylene capacity (billions of lb per year)	20.0	32.2	39.0	41.7	43.0	47.8
C_2-based	12.2	12.5	13.1	13.1	12.8	12.3
C_3- + C_4-based	3.1	5.7	5.9	6.2	6.5	7.0
C_5- and higher-based	4.7	14.0	20.0	22.4	23.7	28.5
Overall capacity utilization	91%	79%	71%	83%	82%	82%
Ethylene price **1979** (cents per lb)	5.7	14.7	21.8	22.5	23.5	31.3
Current (cents per lb)	3.2	12.6	23.8	33.2	40.9	72.8

Source: SRI International

Chemical &
Engineering NEWS

Fiber monomers thr
through rough year Page
A Key Chemicals Review

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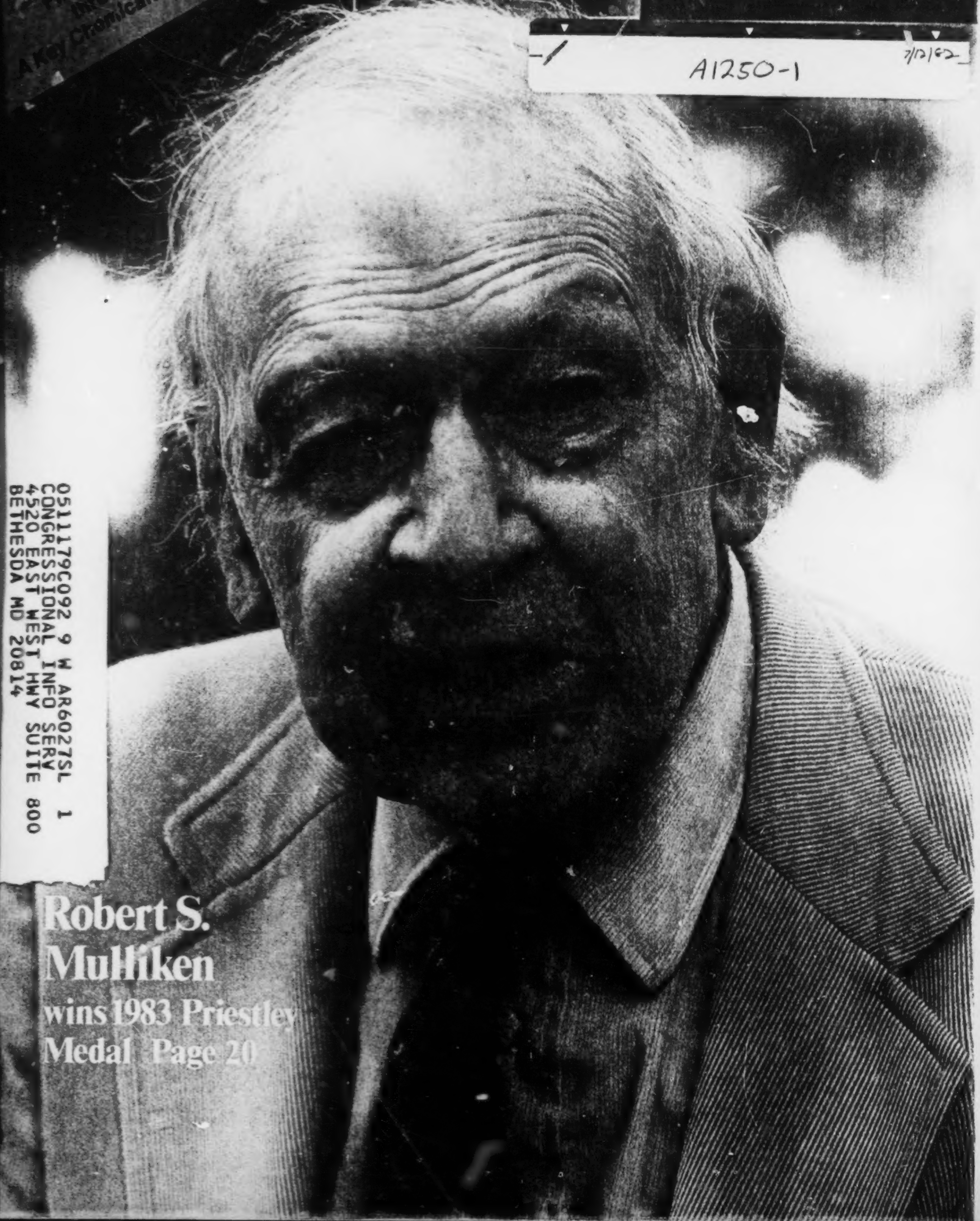

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Robert S. Mulliken

wins 1983 Priestley Medal Page 20

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Chemical & Engineering NEWS

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2 Letters
3 Editor's Page

Concentrates

7 Business
13 Government
17 Science/Technology

The Departments

30 Meetings
40 Newscripts

News of the Week

- ***Texas Eastern*** *acquires engineering firm Halcon SD Group.* ***Page 4***
- ***EPA proposes regulations*** *to determine which small chemical firms are exempt from reporting data under TSCA.* ***Page 4***
- ***Texaco's coal gasification process*** *licensed by Japan's Ube Ammonia Industry Co. to make hydrogen for ammonia plant.* ***Page 5***
- ***Akzona will get new top management,*** *become privately owned by Akzo.* ***Page 5***
- ***Monsanto reorganizes*** *to push research, accelerate growth businesses, and boost support of ag chemicals.* ***Page 5***
- ***Pending acid rain legislation*** *protested by coal and power industries, citing high cost of compliance, incomplete data.* ***Page 6***
- ***Exxon begins cutting personnel,*** *initially through early retirement, thus joining other oil firms facing slowdowns.* ***Page 6***

Business

- ***Fiber raw materials*** *suffer from downturn in housing and clothing markets.* ***Page 8***
- ***IBM Instruments enters lab computer market*** *with program for gas and liquid chromatography, cooperative project.* ***Page 12***

Government

- ***OSHA's proposed rules to protect workers*** *from toxic chemicals called too stringent by industry, too weak by labor.* ***Page 14***
- ***Canadian study*** *of alleged yellow rain attacks in Southeast Asia reinforces earlier U.S. reports.* ***Page 16***

Science

- ***Reactivity of calcium atoms*** *depends on geometry of their approach to molecular targets, research reveals.* ***Page 18***
- ***Formation of cataracts*** *in the eyes of laboratory animals can be detected by using Raman spectroscopy.* ***Page 19***
- ***Supply of chemistry and chemical engineering graduates*** *is greater than demand, according to NSF survey.* ***Page 19***

Priestley Medal

- ***Robert S. Mulliken,*** *1983 Priestley Medalist and Nobel Prize winner for his development of molecular orbital theory, is at home in both chemistry and physics.* ***Page 20***

Salary Survey

Unemployment among chemists rose slightly *since March 1981, ACS member survey indicates; salaries increased but only enough to stay even with inflation.* ***Page 22***

Books

- ***"Life for Sale"*** *attempts to present advances in biotechnology to the general reader but is flawed by journalistic hype.* ***Page 27***

Fiber raw materials follow fibers downturn

Intermediates for polyester and nylon—DMT/PTA, ethylene oxide, and cyclohexane—lose volume and value in recession

Bruce F. Greek
C&EN, Houston

Bare legs, old clothes, and expensive mortgages are the plague of synthetic fibers and, in turn, the chemicals that go into them. Inexpensive fashions and a recession-torpedoed housing market will make 1982 another down year for major organic chemicals used primarily in synthetic fibers.

The prospects for 1982 and beyond for dimethyl terephthalate and purified terephthalic acid (DMT/PTA), ethylene oxide, and cyclohexane are bleak. Combined U.S. production will decline this year and selling prices remain low in spite of efforts to raise them, leaving total value and profits in shambles.

This outlook relates directly to a continuing shakeout in the synthetic fibers business. A year ago, it was viewed generally that fibers had completed a heavy round of plant shutdowns and company exits, leaving capacity quite lean and financial prospects bright in the next economic expansion. Now, a year later, fashion and the world economy have the shakeout going again.

A case in point is Celanese's decision to shut down 200 million lb per year of capacity for polyester filament beginning this August (C&EN, May 31, page 7). Although this capacity is relatively small in the total, it does mean some decline in demand for polyester ingredients, DMT/PTA and ethylene glycol derived from ethylene oxide.

Key Chemicals

Similarly, Du Pont's plans to reduce its nylon fiber production will reduce demand for raw material cyclohexane. Merchant sales of cyclohexane to Du Pont will decline further next year when the company completes it own unit to make part of its cyclohexane requirements.

The continuing shakeout in fiber capacity leads to a serious question of whether sufficient capacity remains to meet future demand. Not everyone agrees on this point, with some expecting an upsurge in demand to cause shortages because of limited capacity. Others, however, expect that capacity could expand quickly to meet demand.

Although there might be a fiber capacity problem, few in the industry anticipate a capacity problem for fiber raw materials. Currently, operating rates for plants making DMT/PTA, ethylene oxide, and cyclohexane are quite low as inventories are worked off. Some pickup in operating rates is expected later in the second half of 1982, which would push the average rate for the year higher than it has been recently.

The worst prospects seem to be for cyclohexane, which may have an average 1982 operating rate of less than 50% of nameplate capacity. This means, of course, that much capacity actually will be shut down during 1982. Longer-term prospects are not very good either, with average annual production gains for the rest of the 1980s at about 2%.

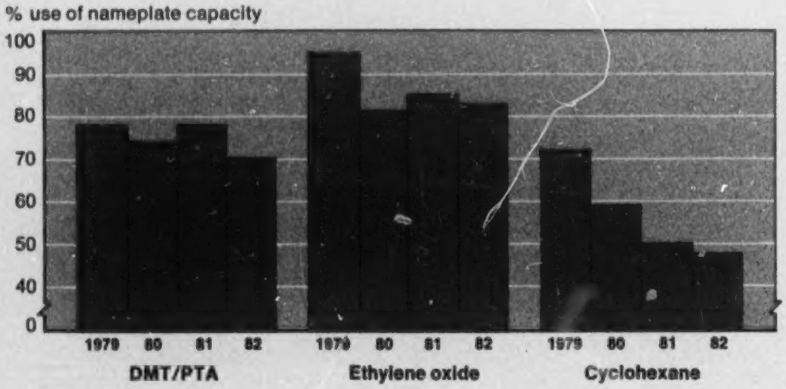
The longer-term outlook for polyester materials is a little better but not much, because their end uses have low growth rates in all but bottles and a few other small nonfiber uses. Ethylene oxide's other major use, antifreeze via the glycol, will at best about match fiber growth because of changes in automobiles and driving habits. Since operating rates for DMT/PTA and ethylene oxide are expected to be 70 to 80% in 1982, with long-term growth rates of 3 to 4%, capacity for these materials could begin to fall short of demand in the second half of the 1980s.

But far more important to producers this year is the anemic state of profit. Combined production will be down, perhaps as much as 600 million lb, or 5%, from 1981 output of 12.5 billion lb. Total value, because of selling price declines, could be down $1.5 billion, or 30% from the early estimate of $5.1 billion for 1981.

Partially offsetting the large value decline is a decline in most raw materials costs. Ethylene's price, for example, has tumbled from about 25 cents a lb to 18 cents, or nearly 30%. Benzene, the major-cost item in cyclohexane raw materials, has declined more than 15%.

Whether selling prices of these intermediates will decline further as such raw materials' prices decline is a matter of argument. The aromatics seem less likely to decline. Ethylene, too, could be at a bottom as supplies of low-cost raw material ethane start to expire.

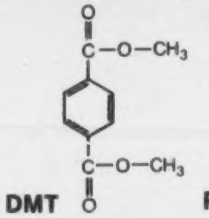
Plant capacity use drops this year for all three



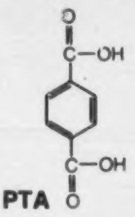
Sources: Industry and C&EN estimates; International Trade Commission

Key Chemicals

DMT/PTA



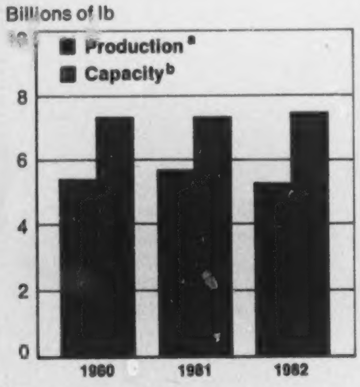
DMT



PTA

- ***Demand well down***
- ***Capacity level***
- ***Prices on hold***

PRODUCTION/CAPACITY



a Total for both DMT and PTA. b First quarter.

HOW MADE

Oxidation of p*-xylene and concurrent esterification to make DMT; oxidation of* p*-xylene to make PTA*

MAJOR DERIVATIVES (U.S.)

Polyethylene terephthalate 95%, polybutylene terephthalate 5%

MAJOR END USES (U.S.)

Polyester fibers 80%, films 10%, bottles, other fabricated forms 10%

FOREIGN TRADE

Exports—300 million lb, imports—negligible

PRICES

List prices about 35 cents per lb for DMT and 38 cents per lb for PTA

COMMERCIAL VALUE

$1.75 billion for production, 1982

U.S. producers of dimethyl terephthalate (DMT) and purified terephthalic acid (PTA) are playing recession poker in 1982 without the ace up their sleeve that let them score surprisingly high in 1981. The odds are against them, even though they might outplay producers of many other organic chemicals.

Luck has been oddly fickle for DMT and PTA over the past several years. Ups and downs seem to alternate no matter what the general economy does. For example, producers this year face an outcome similar to 1980 instead of 1981. Total production of these two derivatives of *p*-xylene could drop this year to as low as 5.2 billion lb. In 1981, despite the sharp U.S. recession beginning in late summer, DMT/PTA output rebounded to 5.7 billion lb because of an export boomlet. This rebound followed a recessionary decline to 5.4 billion lb in 1980 after production peaked at 5.7 billion lb in 1979. If this choppy pattern holds, producers could look toward another gain in 1983.

(These data are industry estimates, which run 10 to 20% below official government figures. Government statistics are considered too high because of double counting of DMT and PTA.)

Because of four years (through 1982) of no new growth in production for DMT and PTA, earlier forecasts for these materials obviously look bad—as do forecasts for many other major organic chemicals. Some of these earlier forecasts included predictions that additional capacity would be coming on stream from now through 1984. Undoubtedly, if demand had kept going as it had in the 1970s, more capacity would have been needed by now.

Fortunately, cool heads prevailed, and no major capacity has been added in the past two years. None is being built now except for minor gains that are really by-products of efficiency campaigns.

This lack of added capacity probably will allow producers to operate nameplate capacity of 7.4 billion lb per year at about an average rate of 70% during 1982. This will be down from an estimated 78% in 1981. Although neither of these rates is a real money-maker for producers, they are fairly good these days for organic chemicals.

The 1981 operating rate was spurred by larger-than-expected exports of derivative polyester, both as fiber and the precursor chips. Exports of DMT and PTA themselves probably were down in 1981 from more than 400 million lb in 1980. At least another 600 million lb (in terms of DMT/PTA) was exported in the form of fibers. Polyester film and molding resins added a small amount.

This year, mainly because of economic changes in various countries and startup of local plants producing DMT, PTA, and polyesters in fabricated forms, U.S. exports are expected to decline substantially. The variables here are many. Long-term operability of the new foreign plants could influence U.S. exports either way: Greater than expected success could mean lower U.S. exports, but startup troubles could keep exports high. The net effect on DMT and PTA production in the U.S. could be between 200 million and 600 million lb.

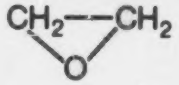
Polyesters will have a diverse market situation in the U.S., too. The bright spot will be the much-talked-about bottle resins. The darker side will be the fibers business.

Bottle resins continue in strong development along with many auxiliaries, especially bottle-making machines. Capacity to make bottle resins seems sufficient, owned mainly by polyester producers. Boosting machines' bottle production rates is now the main challenge to reducing costs in making small-sized polyester bottles.

The fiber side of polyester will not match 1981 demand in 1982—for many reasons. One is that the price of competing cotton has declined roughly a third from its peak, even though cotton futures currently are rebounding. This makes cotton relatively more attractive in blends with polyester. The lower cotton price also tends to make all-cotton garments cheaper to produce, allowing firms more promotional money to push sales. Another factor is a continued shift toward informal clothes, which has cut into sales of polyester blends with wool. U.S. consumption of DMT and PTA as a polyester fiber could be off 100 million lb in 1982.

On balance, the 1982 outlook for DMT and PTA in the U.S. calls for a rough balance between a gain in bottles and other nonfiber uses and a decline in fibers. The real blow is expected in derivatives exports.

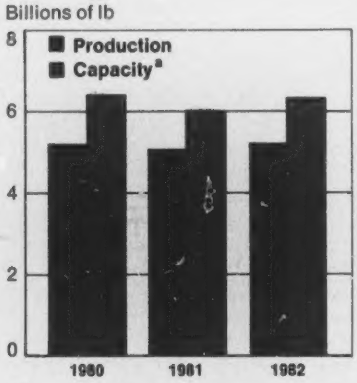
Key Chemicals



Ethylene Oxide

- ***Demand flat***
- ***Capacity back up***
- ***Prices badly discounted***

PRODUCTION/CAPACITY



a First quarter. **Note:** Capacity figures exclude units indefinitely shut down, about 0.5 billion lb in 1982.

HOW MADE

Vapor-phase oxidation of ethylene with oxygen or air

MAJOR DERIVATIVES (U.S.)

Ethylene glycol 60%, ethoxylates 10%, glycol ethers 10%

MAJOR END USES (U.S.)

Polyester fibers and films 30%, antifreeze 25%, surfactants 10%

FOREIGN TRADE

Exports—small, decreasing; imports—small, possibly increasing

PRICES

List prices up to 45 cents a lb, with discounts up to a third of list

COMMERCIAL VALUE

$1.5 billion for production, 1982

Like a ship traveling through a storm on gyroscopic control, ethylene oxide is displaying notable stability for an organic chemical in the current severe recession. Production and plant capacity aren't growing, but they aren't in danger of capsizing either as are a great many other products. And capacity use in operating units has stayed decently high. True, ethylene oxide's merchant price is in shambles, but its open-market sales are small.

This doesn't mean, however, that ethylene oxide is steaming through a great year. To producers, 1982 marks the third straight year on a plateau about 9% below the product's 1979 record production of 5.7 billion lb. The range of volume estimated for 1982 is remarkably small. Analysts say that if the economy does a modest turnaround in the second half, aiding automobile sales and housing, production of ethylene oxide could reach 5.2 billion lb. If there is no such bounce, production likely will run 5 billion lb or a bit less.

Since production topped out in 1979, it has fluctuated around 5.2 billion lb. Most industry sources don't expect to see the 1979 mark exceeded until 1983, if then. But production won't decrease much either, because ethylene oxide has staying power in the event of a renewed downturn.

Assuming production stays in the expected range in 1982, ethylene oxide plants will run at an average rate of about 80% of operable nameplate capacity for the year. Capacity as the year opened was about 6.3 billion lb.

This capacity figure has become an elusive item in recent years. Some capacity, nearly 1 billion lb out of a nominal total of 6.8 billion lb, has been shut down so long that few people expect it to run again. Other capacity continues to grow without plant additions because of process technology improvements, especially catalyst changes. To complicate things a bit more, some of the shutdown capacity, possibly 300 million lb per year, will materialize again as PPG Industries, in cooperation with Du Pont, moves a unit from Puerto Rico to Beaumont, Tex. So next year, thanks to debottlenecking, technology improvements, and startups, capacity probably will increase 300 million lb, or about 5%, to 6.6 billion lb.

Ethylene oxide has one dominant use, ethylene glycol, which in turn has two major outlets in polyesters and antifreeze. Ethylene glycol takes 60% of ethylene oxide production, with much of the conversion done in units right next to oxide units. All ethylene glycol producers make ethylene oxide. Many appear to have enough nameplate capacity in excess of glycol needs to make some sales in the merchant (open) market.

Of the glycol's two major markets, polyester continues to get the nod as the main future growth outlet for ethylene oxide. Even so, polyester fibers aren't doing well. They currently have a bit more competition than usual, since cotton prices, even after a slight rebound, are relatively low. This induces textile producers to increase the cotton content of polyester-cotton blends. Somewhat offsetting the cotton price have been low prices for polyester's raw materials, ethylene and *p*-xylene, as a result of the slump in crude oil prices.

Polyester fibers have another problem in 1982 because of a decline in exports. However, polyester bottle resin likely will provide enough growth to have a favorable impact on total polyester use of ethylene oxide. If the decline in exports proves larger for the entire year than now forecast, then the bottle resin use will not be big enough to offset total fiber decline. This scenario leads to some industry estimates that 5 billion lb might be all the ethylene oxide produced in 1982.

Antifreeze continues to disappoint producers and forecasters. This year "original fill" demand fell below expectations because of a decline in both size and production of U.S. cars. Replacement antifreeze demand also has not come up to expectations even with increased car life. Another flat year for antifreeze seems likely.

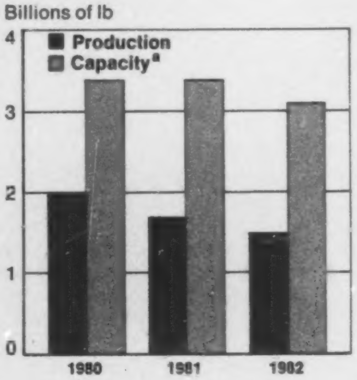
Weak demand for ethylene glycol derivatives carries back to the oxide in downward price pressure. Although ethylene oxide's merchant volume is only roughly 10% of production, competition has forced horrendous (up to one third) discounts this winter and spring from list prices of typically 45 cents per lb. Small increases in real selling prices were attempted as the third quarter opened, but it is too early to tell if the increases will hold.

Key Chemicals

Cyclohexane

- ***Demand way down***
- ***Capacity also down***
- ***Prices fluctuating***

PRODUCTION/CAPACITY



[a] First quarter.

HOW MADE

Catalytic hydrogenation of benzene; recovery from natural gasoline

MAJOR DERIVATIVES (U.S.)

Adipic acid 60%, caprolactam 30%

MAJOR END USES (U.S.)

Nylon 66, 60%; nylon 6, 30%

FOREIGN TRADE

Exports—may recover after large decline in 1981, imports—negligible

PRICES

$1.64 per gal list; follows benzene price, currently with small discount

COMMERCIAL VALUE

$375 million for production, 1981

Cyclohexane is one of the disaster zones in organic chemicals this year, dealt an exaggerated blow by the recession through crippled end-use markets in housing and clothes. If that weren't enough, the product faces a plant shakeout in the next few years because of demand shifts and a basic change in raw material hydrogen costs.

Cyclohexane production will be down as much in 1982 as it was in 1981. More than 600 million lb less product is being produced during these two years as output drops from 1.96 billion lb in 1980 to about 1.5 billion lb this year.

At the same time, plant capacity is off nearly 300 million lb per year because of an exit by financially troubled Commonwealth Oil in Puerto Rico. At the beginning of 1982, the industry's cyclohexane capacity was about 3.1 billion lb per year. Other production units are shut down temporarily or will be, much as in 1981. Total nameplate capacity will run at less than a 50% rate on average this year.

No additional capacity will come on stream in 1982. Du Pont's planned cyclohexane plant near Corpus Christi, Tex., with unconfirmed capacity of about 300 million lb a year, is due in 1983. This plant, marking Du Pont's entry into this business, will get its raw material hydrogen from the company's adjacent chlor-alkali plant. Such sourcing will give Du Pont, a large cyclohexane user, an advantage that most other producers do not have.

Hydrogen could become a key factor in the future of cyclohexane capacity, according to some industry sources. Generally, a majority of cyclohexane is produced by units adjacent to oil refineries, where catalytic reforming units throw off coproduct hydrogen along with mixed aromatics streams. Refineries' own demand for hydrogen has escalated for hydrotreating heavier, more sour (higher sulfur content) crude oils. The coproduct hydrogen from reforming is considered low cost; thus refiners will use it as fully as possible before building a separate unit to make hydrogen. Hence, if the refiners' cyclohexane business brings a low return on investment because of relatively low prices and operating rates, refiners will tend even more to put hydrogen to other uses and shut down cyclohexane units. As usual, the smaller units, except for those with special sales circumstances, are the prime candidates for closing.

Recovery in demand for cyclohexane depends absolutely on nylon, its overwhelming end use. Nylon has been poor business in the past two years, because of the same depressed housing and clothing markets hurting other parts of the chemical industry. Optimistically, improvement in nylon and, in turn, cyclohexane, might bring a return to 1980 production levels by the end of 1983. After that, there could be slow average growth, possibly 3% annually. Pessimists, however, expect a decade to pass before cyclohexane production again matches the previous high in 1979 of 2.4 billion lb.

That pessimists seem to prevail is evidenced in nylon plant shutdowns, which have started again in recent months. Nylon's major use (nearly 60%) is in carpets, which are suffering from the decline in housing and in replacement of worn items.

Cyclohexane does even worse than nylon and can't grow so much in the future. First, not so much cyclohexane goes into carpets proportionately as does nylon because some nylon is made using phenol raw material. Further, a shift continues toward use of alternative butadiene for making hexamethylenediamine, one component of nylon 66.

Other uses for cyclohexane are small, mostly in solvents. None of these are believed to have much growth in the near future.

Except for exports, cyclohexane is just about a one-outlet material. As goes nylon, so goes cyclohexane. Nylon's prospects are poor to fair depending on the end market. For example, in carpets, nylon continued to grow until the current recession, partly through capture of markets from other fibers. But in tire cord, nylon will continue to slip unless heavy-duty truck and off-the-road tires, a nylon preserve, take significantly larger shares of the total tire cord market.

For the rest of 1982 and 1983, cyclohexane will have to hold onto a weak position at the beginning of a long pipeline to eventual durables consumers, who continue to limit their spending drastically.

IBM Instruments introduces lab computer

Separation instruments show faster growth . . .

Sales, $ million	1981	1985
Gas chromatography	$318	$ 555
Liquid chromatography	240	515
Other	100	120
Subtotal	$658	$1190

. . . but characterization instruments dominate sales

Sales, $ millions	1981	1985
NMR-EPR	$ 140	$ 185
Infrared	118	160
UV/visible	163	220
Atomic absorption	191	280
Nuclear, x-ray	200	260
Mass spectrometry	165	225
Electron microscopy	120	150
Electrochemistry	125	165
Other	175	230
Subtotal	$1397	$1875
TOTAL[a]	$2055	$3063

[a] Items do not add to total because of rounding. Source: IBM Instruments

Competition among instrument makers to automate analytical laboratories has intensified a bit further with the introduction of a lab computer by IBM Instruments. The firm thus joins Perkin-Elmer and Hewlett-Packard as a supplier of computer systems to run instruments, reduce data, print reports, and keep records (C&EN, March 9, 1981, page 30).

IBM Instruments president Cecil P. Webb says analytical instruments and computers to guide them are a logical market for the parent company. "The global message is that IBM will compete in the eighties in all facets of the growth of the information processing industry. We are a specific example of that message." Webb estimates that worldwide instrument sales totaled more than $2 billion in 1981, growing at 11% per year in constant dollars.

The IBM laboratory computer entry is a compact unit containing a keyboard, multicolor printer/plotter, cathode ray tube (CRT), and 128 kilobytes each of random access memory (RAM) and read-only memory built around a Motorola 68000 microprocessor. A byte is an eight-bit "word" of instruction or information. Chemists would use the RAM memory for programing; the microcomputer itself uses the read-only memory to translate the BASIC language, to diagnose any malfunctions, and generally to run itself.

For now, the only dedicated instrument program IBM furnishes is for gas and liquid chromatography. The IBM machine can run up to four chromatographs. Thus the unit and software seem equivalent to Perkin-Elmer's Sigma 15 "smart" terminal to run chromatographs. The IBM unit's memory can be expanded to an additional 5 megabytes of RAM by insertion of cards containing up to 1 megabyte each. This expanded memory plus possible future programs for various spectrometries might make the IBM microcomputer roughly equivalent to Perkin-Elmer's Model 3600 terminals that run one spectrometer each. Like the 3600, IBM's microcomputer also can serve as host computer to others of its kind for general laboratory management and record keeping.

Motorola has promised improvements in the 68000 central processing unit that may make it competitive with more costly and complex minicomputers. The present information processing rate of 8 MHz will be expanded first to 12 MHz, then to 16 MHz, in the next few years. Amounts of information processed at each step will increase from 16 to 32 bits. Thus the IBM microcomputer eventually could have the capability to manage several dozen instruments as host computer.

IBM Instruments also is involved in a cooperative project with analytical chemistry professor Thomas C. Farrar, of the University of Wisconsin, Madison, to develop programs to let its microcomputer run a Fourier-transform nuclear magnetic resonance spectrometer (FT-NMR). Farrar bought an IBM Instruments FT-NMR spectrometer and microcomputer with a National Science Foundation grant. He hopes to use the microcomputer to increase spectrometer productivity and as a teaching tool. Eventually, Wisconsin investigators will need the spectrometer for only a few minutes per sample, moving the data to the less costly microcomputer for the few tens of minutes needed for further processing. Students also would not need to tie up the spectrometer to learn to run it, as professors simply could furnish raw data to students for processing on a microcomputer.

Since its founding just two years ago, IBM Instruments (headquartered in Danbury, Conn.) has moved with slow deliberation toward its goal of becoming a dominant factor in analytical laboratory instruments and computing. The company has taken each step only when ready, gaining access to strengths it lacks. The firm bought what Cecil Webb describes as a large but noncontrolling interest in the Bruker group of companies—Bruker Physik, of Karlsruhe, West Germany; Bruker-Spectrospin, of Zurich, Switzerland; and Bruker Instruments, of Billerica, Mass. IBM and Bruker collaborated in the design of the FT-NMR, FT infrared, and electron spin resonance spectrometers that Bruker builds for IBM. IBM also has farmed out production of the liquid chromatographs and even the microcomputer it designed and sells. The IBM parent company's manufacturing costs are too high for the few thousand computers IBM Instruments needs yearly, so the subsidiary company contracted with another manufacturer for production. This conservative attitude makes managers reluctant to disclose future plans, which presumably include additions to the instrument line as well as compilation of a library of programs dedicated to each instrument type.

The liquid chromatography program simplifies instrument operation partly by assigning functions to a bank of 57 general-purpose keys on the keyboard. The firm provides an overlay that the user places over these keys. The keys then specify the timing, proportions, and flow rates of up to three solvents in the chromatograph, as well as control experimental conditions and time length.

The company has tried to increase computer serviceability and to lower service costs by including a troubleshooting program. If the user can identify the defective part, interchangeable parts can be exchanged by courier to avoid costly service calls. IBM Instruments engineers also consult with users by phone, and provide courses in computer repair. As is the case with some of its competitors, IBM Instruments provides a "wet" laboratory and library for prospective customers to prepare samples and continue with their own work while on lengthy visits to IBM to evaluate instruments. The laboratory and library, which has a computer tie-in to several scientific data bases, are also available for cooperative projects between IBM Instruments and other companies.

Steve Stinson, New York

Unemployment rises slightly for chemists

Chemists' salaries also are up moderately, but inflation wipes out the gain, annual survey of ACS members indicates

The employment scene for U.S. chemists has darkened slightly but perceptibly this year. Unemployment among chemists who are members of the American Chemical Society had edged up to 1.5% of the total as of last March, after having hovered close to 1% in each of the three preceding years.

Even so, chemists are far less likely to be out of work than is the case with most other segments of the U.S. labor force. The current sharp economic recession has sent unemployment in the U.S. soaring since last summer to the highest levels since just before the U.S. entered World War II. The unemployment rate nationwide was 9.0% of the labor force in March, according to the Bureau of Labor Statistics; since then it has climbed still further, reaching 9.5% in May. The rate for professional and technical workers alone, although considerably lower, also is rising; it was 3.2% this past March, up from 2.7% a year earlier. Although these broader figures dwarf the unemployment rate for chemists found by the latest annual survey of the economic status of ACS members, conducted by the ACS Office of Manpower Studies in March, the rate for chemists has not been higher since 1976.

Salaries earned by chemists, meanwhile, have improved only moderately during the past year, the ACS survey indicates. The median salary for all Ph.D. chemists last March was up just 7% from March 1981's median to $37,500. (The median is that which is exceeded by 50% of the individuals responding to the survey.) Last year, the median salary for Ph.D.s had increased 12% and the year before it had risen 8%.

Ph.D. chemists, nevertheless, fared better during the past year than their colleagues holding lower degrees. For chemists whose highest degree is a B.S., the median salary was up only 4% from a year ago, the smallest year-to-year gain since 1976, to $28,500. They had garnered a 10% increase in 1981 from the previous year. The increase this year for chemists with an M.S. was 5% to $31,600, well below the 15% gain they had enjoyed the year before.

As has been the case in the past, moreover, this year's improvements in chemists' salaries have been eroded by inflation. Consumer prices increased 7% between March 1981 and March 1982. Thus, for Ph.D. chemists, the past year has been a standoff between higher income and a higher cost of living. And both B.S. and M.S. chemists actually lost ground. In constant dollars, the median salary for B.S. holders is 3% lower than in 1981; for chemists with an M.S. it is down 1%.

The further decline of the worth, in terms of purchasing power, of chemists' salaries this year merely extends a trend that has been under way almost unremittingly since 1973, even though the rate of inflation has subsided markedly during the past year. (Consumer prices increased an average of 11.5% in 1979, 13.5% in 1980, and 10.2% last year, but have increased only 6.7% in the past 12 months.) If allowance is made for the impact of inflation, therefore, median salaries for chemists with a B.S. degree are 22% less than nine years ago, and those for chemists with graduate degrees about 17% less.

Chemists also are not keeping up

Unemployment remains relatively low for ACS members across the board . . .

	CHEMISTS								Chemical engineers	All ACS members[c]
		By sex		By highest degree			By minority status			
Employment status[a]	Total	Men	Women	B.S.	M.S.	Ph.D.	Minority[b]	Nonminority		
Employed full time	94.0%	95.2%	86.4%	94.1%	96.2%	93.3%	89.2%	94.5%	94.6%	93.9%
Employed part time	1.4	0.9	4.2	1.8	1.3	1.2	1.1	1.3	1.5	1.4
Postdoctoral or fellowship	2.2	2.0	3.7	0.1	0.3	3.7	7.2	1.8	0.6	1.9
Unemployed										
Seeking employment	1.5	1.3	2.8	2.2	1.4	1.3	1.7	1.5	1.6	1.7
Not seeking employment	0.9	0.6	2.9	1.7	0.8	0.6	0.7	0.9	1.7	1.1

a As of March 1, 1982. b Black, American Indian, Alaskan native, Asian or Pacific, Hispanic, or other. c Includes members whose highest degree and present work are neither in chemistry nor chemical engineering. **Source:** ACS survey

. . . and salary increases are relatively modest

$ Thousands	1982	1981	1980	1979	Change 1981–82
CHEMISTS' MEDIAN SALARIES[a]					
B.S.	$28.5	$27.5	$25.0	$23.5	4%
M.S.	31.6	30.0	26.0	25.0	5
Ph.D.	37.5	35.0	31.2	29.0	7
All chemists	34.7	32.0	28.9	na	8

$ Thousands	1982	1981	1980	1979	Change 1981–82
CHEMICAL ENGINEERS' MEDIAN SALARIES[a]					
B.S.	$40.0	$36.0	$35.0	$31.7	11%
M.S.	42.0	40.0	35.0	31.5	5
Ph.D.	45.0	42.0	38.0	35.0	7
All Ch.E.s	42.0	39.2	36.0	na	7

a As of March 1, 1982. na = not available. **Source:** ACS survey

Experience affects salaries, although more-experienced chemists may not earn more

Years since B.S. degree	Annual salaries of nonacademic chemists ($ thousands)[a]										
	0 to 1	2 to 4	5 to 9	10 to 14	15 to 19	20 to 24	25 to 29	30 to 34	35 to 39	40 or more	Overall
B.S.											
90%	$25.1	$25.9	$32.0	$39.3	$46.7	$49.2	$52.1	$55.9	$72.5	$60.0	$48.0
75%	22.0	23.8	28.5	33.0	39.0	41.0	44.9	47.7	54.7	50.0	37.2
Median	20.0	21.0	25.0	28.0	33.9	35.0	37.0	38.0	43.0	40.9	29.0
25%	18.0	18.3	21.2	24.0	28.0	29.5	30.0	32.2	34.9	34.1	22.5
10%	15.6	16.0	18.3	20.9	25.0	24.0	26.4	25.0	25.9	30.0	18.7
M.S.											
90%	—	28.8	32.5	41.9	49.2	52.0	53.8	62.9	54.5	73.4	50.0
75%	—	26.0	30.0	35.0	40.0	43.1	46.6	49.1	47.5	55.0	41.0
Median	—	24.0	25.5	30.0	33.6	36.2	40.0	40.4	37.8	43.0	33.0
25%	—	20.7	22.0	26.0	29.1	30.0	34.0	34.6	32.0	35.5	26.6
10%	—	18.9	19.0	22.0	25.9	25.3	25.0	30.0	23.7	28.2	22.0
Ph.D.											
90%	—	—	38.0	46.0	52.0	62.4	69.0	70.0	70.0	76.0	60.0
75%	—	—	35.0	40.0	45.0	52.1	57.5	60.0	57.5	63.8	50.0
Median	—	—	32.5	36.0	40.0	45.5	48.0	51.0	49.1	51.0	41.2
25%	—	—	30.0	32.0	35.0	40.0	40.5	44.0	41.0	42.0	34.8
10%	—	—	28.0	29.0	30.3	33.6	35.0	36.0	35.5	36.5	30.0

[a] As of March 1, 1982. **How to read this table:** Using as an example, B.S. chemists two to four years after having received their B.S. degree, 90% of these chemists have annual salaries of $25,900 or less, 75% have salaries of $23,800 or less, 50% have salaries of $21,000 or less, 25% have salaries of $16,300 or less, and 10% have salaries of $16,000 or less, as of March 1, 1982. **Source:** ACS survey

with blue-collar workers in the chemical industry when it comes to raises. Hourly wages for production workers in chemical plants increased 9% during the 12 months to March 1982, but salaries of chemists in industry were up 8% if they have a Ph.D. and just 4% if their highest degree is either a B.S. or an M.S.

The overall median is only a very rough indication, of course, of how much an individual chemist earns. Salaries vary widely depending on whom chemists work for, the type of work they do, and how long they have been on the job. Because years of experience is such a significant factor in determining salary levels, this year's report on the annual ACS salary survey presents a more detailed breakdown of salary data on the basis of experience than previously (see page 24). In addition, some of the data are adjusted to compensate for differences in length of experience among various groups.

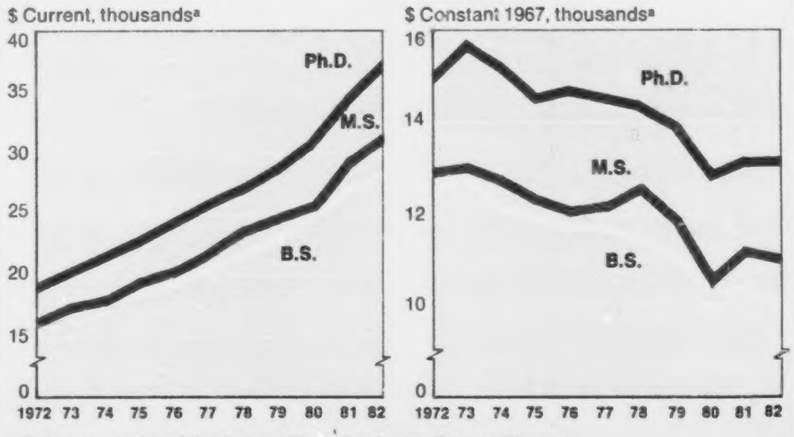
Among the latter are data indicating the difference between salaries earned by men and those earned by women. Men typically have received higher salaries than women, and this continues to be the case this year. For example, among chemists with a B.S. working in industry, median salaries of women are 75% of those of men. For those with an M.S., the women earn 78% of what men earn at the median level. And among Ph.D. chemists, in industry, women earn 80% of what men earn.

These figures do not make allowance, however, for the fact that in the overall sample of industrial chemists, women tend to be younger and hence less experienced than their male counterparts. This would result in a lower median salary for women even if, at any given level of experience, salaries of men and women were equal. Among women chemists in industry, for instance, only 16% received their B.S. degree 20 or more years ago but 48% of the men did so.

If the data are adjusted for this difference in length of experience between the sexes, the gap in salary differentials narrows, although it by no means disappears. On an experience-adjusted basis, women's median salaries are 88% those of men's for industrial chemists with a B.S. degree, 83% for those with an M.S., and 96% for those with a Ph.D. The difference between salaries of men and women is even smaller among chemists who obtained their B.S. degree less than 10 years ago.

Gender is only one factor affecting salaries for industrial chemists. Individuals holding research management or general management positions are likely to earn more than

The increase in chemists' salaries this year... **...was not enough to outpace rising prices**



[a] Median annual salary of chemists as of March of each year. **Source:** ACS survey

Chemists tend to earn more if they are men, working as managers, dealing with polymers

Years since B.S. degree		Median salary of chemists ($ thousands)[a]										
		0–1	2–4	5–9	10–14	15–19	20–24	25–29	30–34	35–39	>=40	Overall
CHEMISTS EMPLOYED FULL TIME IN INDUSTRY												
Sex												
Men	B.S.	$21.0	$22.0	$26.0	$30.0	$34.6	$36.8	$37.5	$40.0	$45.4	$40.0	$30.6
	M.S.	—	24.2	26.6	30.8	35.0	40.0	42.3	42.0	38.5	43.0	35.0
	Ph.D.	—	—	33.0	36.7	41.5	46.8	50.0	52.5	50.0	54.3	42.8
Women	B.S.	20.5	20.5	25.0	25.0	35.1	32.7	(32.0)	(29.5)	—	—	23.0
	M.S.	—	(24.3)	24.8	27.6	30.5	32.0	(37.5)	(30.5)	—	—	27.3
	Ph.D.	—	—	33.5	33.8	38.0	(35.6)	—	—	—	—	34.4
Work function												
General management	B.S.	—	(24.0)	27.0	34.5	36.9	39.1	39.2	50.0	48.6	(40.0)	40.0
	M.S.	—	—	—	35.0	(41.0)	(40.0)	49.3	49.4	(48.0)	—	43.4
	Ph.D.	—	—	—	44.0	46.0	60.0	55.0	57.5	60.0	(70.0)	50.0
R&D management	B.S.	—	—	25.5	32.5	38.0	43.0	48.0	45.0	53.8	50.0	40.0
	M.S.	—	—	(30.0)	36.5	40.0	46.2	(44.7)	47.0	(40.0)	(53.4)	42.8
	Ph.D.	—	—	34.0	43.0	46.0	53.0	59.0	60.5	51.0	62.9	51.0
Basic research	B.S.	20.4	20.9	24.0	30.0	—	(36.0)	—	(35.3)	—	—	23.0
	M.S.	—	(20.3)	25.0	30.8	(35.2)	(34.0)	—	(42.7)	—	—	29.6
	Ph.D.	—	—	33.0	36.0	41.0	46.2	51.0	49.0	—	(51.8)	38.0
Applied R&D	B.S.	21.5	21.6	24.8	27.7	34.5	36.0	36.9	37.0	39.5	38.5	27.0
	M.S.	—	24.6	25.2	29.5	33.0	33.0	41.0	37.9	36.4	41.0	31.7
	Ph.D.	—	—	32.5	35.0	38.7	43.8	45.6	48.0	45.1	49.0	38.6
Work specialty[b]												
Chemical engineering	B.S.	(25.0)	26.5	30.0	32.0	38.3	41.0	47.0	46.9	55.0	47.0	40.0
	M.S.	—	(29.8)	32.0	34.9	48.7	41.5	47.1	50.5	47.0	51.7	43.5
	Ph.D.	—	—	—	39.1	46.0	55.0	49.7	51.3	56.1	60.0	47.7
Biochemistry	B.S.	—	—	(23.7)	—	—	—	—	—	—	—	22.7
	M.S.	—	—	(21.9)	(32.5)	—	—	—	—	—	—	29.0
	Ph.D.	—	—	(31.5)	35.4	37.5	46.8	(49.0)	(64.5)	—	—	39.5
Agricultural chemistry	B.S.	—	20.2	26.5	27.7	—	(42.5)	—	35.0	(48.3)	—	28.0
	M.S.	—	—	(25.0)	30.3	—	—	(37.4)	(40.0)	—	—	34.0
	Ph.D.	—	—	32.2	36.0	39.4	42.6	43.5	50.5	(50.0)	—	42.0
Analytical chemistry	B.S.	21.0	21.0	25.0	28.0	34.5	33.0	36.8	37.0	41.4	37.0	27.0
	M.S.	—	(23.0)	26.2	30.0	32.5	35.9	39.0	38.2	34.0	(33.5)	30.6
	Ph.D.	—	—	33.0	36.2	39.5	45.8	47.0	52.1	45.5	55.5	38.9
Environmental chemistry	B.S.	—	19.4	27.2	29.5	(38.9)	—	—	38.0	—	—	29.0
	M.S.	—	—	24.5	33.3	(40.6)	—	—	41.0	—	—	35.5
	Ph.D.	—	—	—	(36.0)	(31.5)	48.4	(51.0)	47.0	(50.5)	—	44.0
Organic chemistry	B.S.	21.0	21.6	26.3	34.0	34.5	40.0	40.1	40.0	51.6	41.7	31.0
	M.S.	—	—	30.0	30.0	37.4	40.0	43.4	39.5	48.0	(40.0)	36.4
	Ph.D.	—	—	33.0	38.0	43.5	47.0	52.0	50.8	50.0	51.0	43.1
Inorganic chemistry	B.S.	—	22.0	(25.7)	(30.0)	—	—	—	36.0	—	—	29.0
	M.S.	—	—	(26.6)	—	—	—	—	(47.0)	—	—	38.4
	Ph.D.	—	—	32.3	35.0	38.6	50.0	47.2	—	—	—	37.0
Pharmaceutical chemistry	B.S.	—	20.2	24.5	26.4	(26.9)	36.0	(36.5)	(40.0)	(47.1)	—	25.9
	M.S.	—	(19.4)	24.6	30.2	32.0	(33.5)	—	(44.0)	—	—	31.0
	Ph.D.	—	—	31.4	35.0	42.0	48.7	51.4	59.6	44.0	70.0	42.2
Physical chemistry	B.S.	—	—	—	—	—	—	—	—	—	—	29.0
	M.S.	—	—	—	—	—	—	—	—	—	—	41.0
	Ph.D.	—	—	35.4	36.2	43.2	46.2	50.8	50.0	(50.6)	49.0	43.5
Polymer chemistry	B.S.	(21.6)	22.5	26.0	31.0	35.2	40.0	38.5	42.7	40.0	48.0	33.2
	M.S.	—	(24.8)	29.7	32.0	35.0	33.0	41.1	43.3	(38.0)	(44.0)	34.0
	Ph.D.	—	—	33.0	38.0	42.0	46.8	51.0	54.7	49.5	59.0	43.5
CHEMISTS EMPLOYED FULL TIME IN ACADEMIA (PH.D.s ONLY)												
Ph.D.-granting schools												
	Professor	—	—	—	—	$35.0	$37.0	$40.0	$42.9	$42.5	$48.4	$41.0
	Associate professor	—	—	—	$30.2	30.0	30.0	29.0	(31.5)	—	(27.5)	30.0
	Assistant professor	—	—	$21.0	23.0	23.0	30.6	—	—	—	—	23.0
Non-Ph.D.-granting schools												
	Professor	—	—	—	—	28.2	29.0	30.4	30.0	30.0	32.5	29.7
	Associate professor	—	—	—	22.5	23.0	24.0	26.5	—	—	—	24.0
	Assistant professor	—	—	18.0	19.5	19.3	(21.5)	—	—	—	—	19.2

a As of March 1, 1982. b Refers to current work, not field in which degree was obtained. **Note:** Where no salary data are shown, sample is too small to provide meaningful figure; data in parentheses are from relatively small samples as well and should be treated with caution. **Source:** ACS survey

Salary advantage of men compared to women tends to be least among Ph.D.s

Mean salary, $ thousands[a]	B.S.				M.S.				Ph.D.			
	All chemists	Men	Women	Women as % of men	All chemists	Men	Women	Women as % of men	All chemists	Men	Women	Women as % of men
EMPLOYER:												
Private industry	$32.2	$32.6	$28.7	88%	$36.2	$36.8	$30.4	83%	$46.1	$46.3	$44.2	96%
College/university	30.1	30.7	27.1	88	33.7	34.7	25.0	72	40.8	41.6	37.0	89
Government	26.8	27.4	24.6	90	31.3	33.0	25.7	78	39.8	39.9	38.6	97
Other nonacademic	24.1	24.7	20.3	82	23.5	24.9	19.4	78	31.1	31.5	26.0	83

a As of March 1, 1982: to facilitate comparison, salaries are adjusted for differences in the average experience for each group. **Source:** ACS survey

those directly involved with doing research and development. And although most chemists in industry have few if any subordinates—nearly 30% have nobody working for them and another 30% supervise only one or two other people—the relatively few who are responsible for a large number of other workers are compensated duly for that responsibility. The median salary for chemists with about 20 or more subordinates—who represent about 10% of all industrial chemists—is more than 50% higher than that for chemists who supervise nobody at all. And the median for those with 50 or more subordinates—less than 4% of the total—is double that for chemists with none.

Chemists' salaries also vary appreciably from industry to industry. As in the past, salaries tend to be highest for those working in the petroleum industry, which employs 6% of all chemists in industry. The chemical industry itself—where more than a third of industrial chemists work—ranks second in salary levels, followed by the pharmaceutical industry. Differences are relatively slight, however, for the 42% of chemists who have jobs in industries other than these three.

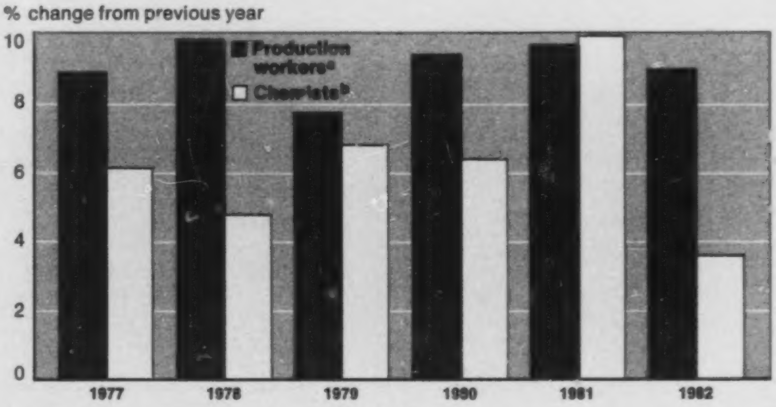
As in the past, as well, chemical engineers responding to the ACS survey have appreciably higher salaries than do chemists. The median for engineers is 40% higher for individuals whose highest degree is a B.S. and

As number of subordinates increases, so do salaries

Number of subordinates	Median annual salaries,[a] chemists in private industry ($ thousands)			
	All chemists	B.S.	M.S.	Ph.D.
ALL SUBORDINATES				
0	$30.0	$24.5	$29.4	$37.5
1–2	35.5	29.4	32.9	38.0
3–7	38.0	31.1	35.5	42.0
8–12	44.0	36.2	36.2	48.0
13–17	48.0	43.0	43.5	52.0
18–22	48.0	37.2	40.0	50.0
23–32	51.2	43.5	48.7	55.0
33–47	59.0	50.0	50.0	63.0
48–67	60.0	51.2	45.5	63.7
68–99	64.6	53.0	57.0	70.0
100 or more	70.0	65.5	52.0	74.4
PROFESSIONALS AND TECHNICIANS ONLY				
0	$30.0	$25.0	$30.0	$37.9
1–2	35.5	29.0	32.6	38.1
3–7	38.5	32.0	36.0	43.0
8–12	45.0	39.0	37.5	48.0
13–17	49.2	43.0	42.3	53.2
18–22	48.0	37.0	44.0	51.1
23–32	53.8	42.2	48.3	56.7
33–47	61.0	52.0	51.2	63.5
48–67	62.0	55.9	56.5	65.0
68–99	70.0	—	69.6	72.0
100 or more	75.0	73.5	—	75.0

a As of March 1. **Source:** ACS survey

Plant workers' wages outpace chemists' salaries



a Average hourly earnings in chemicals and allied products industry. b With B.S. degree.
Sources: Bureau of Labor Statistics, ACS survey

Oil industry pays highest salaries for chemists

Industry	% of industrial chemists				Mean salary ($ thousands)[a]			
	All chemists	B.S.	M.S.	Ph.D.	All chemists	B.S.	M.S.	Ph.D.
Chemical	35%	31%	30%	40%	$39.7	$32.8	$37.0	$45.5
Pharmaceutical	17	14	20	17	38.9	31.2	35.3	45.2
Petroleum	6	5	4	8	44.0	35.3	40.7	49.2
Coatings	5	7	5	3	36.5	32.3	34.9	42.4
Food	4	5	5	3	36.0	31.1	33.1	42.4
Metals and minerals	3	4	3	2	35.8	30.5	34.1	44.3
Rubber	2	4	3	1	36.3	33.6	32.4	41.4
Paper	1	1	1	2	38.3	30.7	36.7	40.7
Other manufacturing	20	21	22	19	37.7	31.4	36.5	43.8
Nonmanufacturing	6	8	7	5	35.2	28.8	31.8	43.3

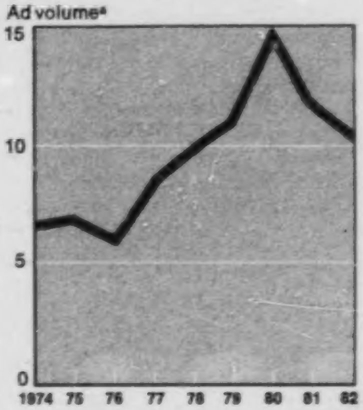
a As of March 1, 1982; to facilitate comparison, salaries are adjusted for differences in the average experience for each group. **Source:** ACS survey

Unemployment among chemists highest since mid-1970s

Employment status[a]	1982	1981	1980	1979	1978	1977	1976	1975	1974
Employed full time	94.9%	95.6%	95.9%	95.0%	95.7%	95.4%	94.7%	95.0%	95.1%
Employed part time	1.4	1.1	1.0	2.0	2.0	1.1	1.3	1.3	1.0
Postdoctoral or fellowship	2.2	2.2	2.2	1.9	1.9	2.1	2.2	2.0	2.5
Unemployed	1.5	1.1	0.9	1.1	1.4	1.5	1.9	1.6	1.4

a As of March 1; excludes unemployed chemists not seeking employment. Source: ACS survey

Help-wanted ads drop to lowest level since 1978



a Volume of help-wanted advertising (in thousands of column inches) in C&EN for the 12 months ending with May of each year.

Age generally a small factor in unemployment

Age	% in category	% unemployed[a]
20-24	2%	2.8%
25-29	11	1.3
30-34	15	1.5
35-39	16	1.8
40-44	15	1.5
45-49	11	1.3
50-54	11	1.7
55-59	10	1.3
60-64	7	1.8
65 and over	2	3.0

a As of March 1, 1982; excludes unemployed chemists not seeking employment. Source: ACS survey

Joblessness varies with what a chemist does

	% in category	% unemployed[a]
MOST RECENT EMPLOYER		
Industry	61%	1.6%
College/university	24	1.3
Government	10	0.8
Other	6	2.6
MOST RECENT WORK FUNCTION		
R&D	38%	1.5%
Teaching	24	1.3
Management[b]	18	1.3
Marketing, production	12	2.2
Other	9	2.1
MOST RECENT WORK SPECIALTY		
Analytical	20%	1.9%
Organic	17	1.1
Polymer	12	1.3
Pharmaceutical	9	1.9
Biochemistry	8	1.6
Physical	7	1.6
Environmental	6	3.0
Inorganic	6	0.7
Agricultural	4	2.0
Other	10	1.1

a As of March 1, 1982; excludes unemployed chemists not seeking employment. b Includes R&D management. Source: ACS survey

20% higher for those who have earned a Ph.D. The salary data for chemists and engineers are not really comparable, however. The engineer respondents tend to be older and more experienced than is the case with the chemists surveyed, for one thing. And engineers account for only a small (9%) part of the overall survey sample, as well as a part that is not representative of chemical engineers as a whole. A disproportionate number of them, for instance, have graduate degrees; 38% of the ACS respondents have a Ph.D., compared to only 16% of the respondents to a similar survey of its members made last year by the American Institute of Chemical Engineers. AIChE members had a median salary of $34,000 in 1981, compared to $39,200 for ACS members who are chemical engineers.

As has been typical in the past, women chemists are more likely to be looking for jobs than are men; 2.8% of the women surveyed were jobless but seeking work last March, up from 2.4% a year earlier; 1.3% of the men were similarly unemployed, up from 0.9% in 1981. (Women also are more likely to be doing postdoctoral work, working part time, or to be out of the job market entirely.)

As in the past, too, chemists whose highest degree is a B.S. are more likely to be looking for a position (2.2%, up from 1.6% in 1981) than is the case for Ph.D. chemists (1.3%, up from 0.8% last year). The greater proportion of unemployed among women and among chemists with no more than a B.S. degree are to some extent interrelated, because among the men in the survey sample only 23% do not have a graduate degree and 60% hold a Ph.D. but among the women 40% have no degree above a B.S. and only 36% have a Ph.D.

It is likely that the employment situation for chemists has darkened further since the ACS survey was completed three months ago. At least that is what is strongly suggested by the volume of classified employment advertising appearing in C&EN in recent months. More advertising of jobs available in chemistry is published by C&EN than by any other U.S. magazine, and the total amount of this advertising in past years has tended to have an inverse relationship to unemployment among chemists.

The volume of such advertising peaked about two years ago and has been dropping erratically since then. In recent weeks, employment ad volume in C&EN had dwindled to only about half what it was just six months ago. It has not been so low as it is at present in nearly a decade.

Most of the data reported here on the employment status and salaries in the chemical profession are drawn from more than 12,000 responses to a survey of ACS members made this past March by the Office of Manpower Studies of the ACS Department of Professional Relations & Manpower Studies. The survey was conducted only among members who are 70 or younger, have a mailing address in the U.S., and are neither student nor emeritus members.

Of the total sample, 84% are chemists, 9% chemical engineers, and 7% do not consider themselves as currently in the chemical profession. Among chemists, 13% are women. A Ph.D. degree is held by 58% of the chemists; 17% have an M.S.; 25% have no more than a B.S.

The ACS Office of Manpower Studies published last month a detailed compilation of data on salaries and employment status based on results from its 1982 survey of ACS members. The full report, "Salaries 1982," can be ordered from the Distribution Office, American Chemical Society, 1155—16th St., N.W., Washington, D.C. 20036. The price of the report this year is $45 a copy. ☐

Chemical & Engineering NEWS

-1

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7/13/82

CEFIC head Jean Gandois calls for self-help by European firms Page 13

New drugs for combating heart disease Page 26

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Chemical & Engineering NEWS

Cover: Heart patient in Finland has electrocardiogram taken during study of effectiveness of gemfibrozil in lowering lipid levels in the blood. Drug is marketed as Lopid by Parke-Davis, division of Warner-Lambert

4 Letters

Concentrates
8 Business
17 Government
20 Science/Technology

The Departments
42 People
52 Newscripts

News of the Week

- ***Imperial Chemical Industries' acquisition*** *of dyes operations of France's PCUK would make it world's fourth largest producer of colorants.* ***Page 6***
- ***NRC revises assessment*** *of probable risk of a major nuclear reactor accident following study of 1969–79 mishaps.* ***Page 6***
- ***First synthetic vaccine*** *is 20-amino-acid peptide that triggers antibodies for foot-and-mouth disease.* ***Page 7***
- ***Diamond Shamrock inches further*** *toward becoming an energy company with bid to buy gas retailer Sigmor Corp.* ***Page 7***

Business

- ***U.S. corporations sweeten employee job transfers*** *with mortgage assistance and various relocation aids as result of changing economic conditions.* ***Page 10***

International

- ***Jean Gandois,*** *head of Rhône-Poulenc and president of CEFIC, urges European industrialists to take the responsibility for their own survival and growth.* ***Page 13***

Government

- ***Proposed changes in New Drug Application procedure,*** *approved by Health & Human Services Secretary Schweiker, will speed up review and save money.* ***Page 18***
- ***EPA regulation on pollutant discharge*** *from inorganic chemical plants sets up effluent limitation guidelines.* ***Page 19***

Science

- ***Newly synthesized organic Möbius strip molecule*** *is one of many of interest for their topological curiosity.* ***Page 21***
- ***Josephson junctions arranged in pairs*** *to form logic gates step up their high-speed capabilities in image processing.* ***Page 23***

Technology

- ***Processes to make fuel-grade methanol*** *from biomass move closer to commercialization in U.S. and abroad.* ***Page 24***

Special Report

New drugs to fight heart disease *include beta adrenergic blockers, calcium channel blockers, and those that lower lipid levels in the blood.* ***Page 26***

ACS News

- ***Petroleum Research Fund grants*** *totaling more than $3.8 million approved by ACS Board of Directors.* ***Page 39***
- ***Reports from committees*** *on Grants & Awards, Public Affairs & Public Relations comprise official board reports.* ***Page 41***

Employee relocation policies expanding

Economic factors are forcing chemical firms to sweeten employee job transfers with mortgage help, relocation assistance, and other aid

Patricia L. Layman
C&EN, New York

Nobody has ever argued that the chemical industry is like the Navy: Join up and see the world. But it always has involved a certain amount of transferring around—from plant to plant, or sales office to sales office—a factor that for a long time was understood and accepted by company and employee alike. The past 10 years, however, have brought some significant changes both to the economics of corporate relocation policies, and to the society that accepts—or increasingly declines—transfers.

Merrill Lynch Relocation Management, one of the major third-party relocation companies, sums up what is happening to some extent in the introduction to its 10th annual study of employee relocation policies of major U.S. corporations. "In the 10 years since this study was first conducted," it says, "significant changes in corporate relocation policies have taken place. This has been due in part to rapidly changing economic conditions."

For example, when Merrill Lynch ran its first study in 1972, inflation was a modest 3% per year, interest rates on home mortgages were only about 6 or 7%, and the average price of a new home was less than $28,000.

Since then, the changing economic scene—most important, the skyrocketing of interest rates—has changed what used to be a fairly calm situation for a company's relocation specialists. Companies have had to scramble to make a job transfer an attractive enough deal for employees to accept. One of the major incentives adopted has been a mortgage-interest differential allowance program. Merrill Lynch, for one, didn't even ask about such programs until 1974, when only 8% of the firms surveyed said they had one. But by 1981, 70% of all firms surveyed had adopted such a program. The figure is even higher in the chemical and plastics industry: Of the 39 companies in that industry that were surveyed, 85% had a mortgage-interest differential allowance.

Similarly, the chemical and plastics industry, on the average, tended to be more generous than business in general in picking up home-sales expenses such as mortgage prepayment penalties, maintenance and repair costs, and realtors' fees; in picking up expenses associated with buying new homes; in reimbursing renters' expenses; and in providing temporary living-arrangement allowances.

But all that comes as no surprise to many relocation specialists. For example, according to H. Cris Collie, executive director of the Washington, D.C.-based Employee Relocation Council, "Chemical companies are among the most enlightened of industries. They have more experience with relocation, and they are in a highly competitive environment, both for new employees and for old ones."

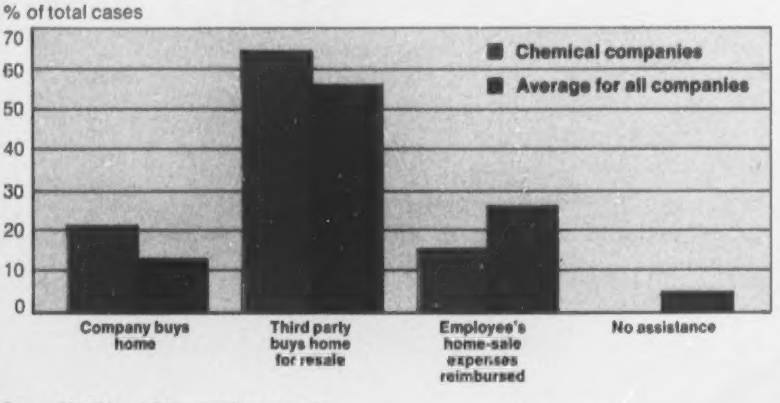
Pearl Meyer, compensation specialist with executive recruiters Handy Associates in New York City, would agree with that. "I would categorize the chemical industry as stable to progressive," she says. "Chemical companies generally are not in the forefront of innovations with their programs, but they are in the luxurious position of not having to be: They can observe how the new ideas are working out in other industries and then take what works well. They are not innovators, but they are very fine implementers."

Corporate relocation specialists say that the economy is forcing them to re-examine their policies, upgrading and expanding them. That helps relieve the financial burden from the employee—only to shift it to the company, which can wind up facing an average cost of $30,000 to $35,000 per move, according to Collie.

Last year, the average number of employees per company transferred in the chemical and plastics industry was 146, down 10% from 1980, according to Merrill Lynch. On the other hand, 1982 probably will see an increase—if only because Union Carbide's move from New York City to Danbury, Conn., completed this spring, probably will skew the results somewhat.

A slowed-down economy, however, has double-edged consequences: It encourages companies to hold down transfers wherever possible, but it also encourages employees to accept a transfer. That was one conclusion, for example, of a survey released last month by Employee Transfer Corp., a Chicago-based relocation company. ETC surveyed employees who were

Chemical companies give better home-sale assistance



Source: Merrill Lynch Relocation Management relocated in 1981 and determined that 84.9% of them would be willing to relocate again. That figure portends a reversal of the four-year downturn in willingness to move that started with 84.4% in 1977 and dropped to 76.3% in 1980.

"Conceivably, the economy is playing a role in inducing more people to transfer as a way to hold onto their jobs," according to ETC officials.

Even without a dampened economy, however, chemical industry relocation specialists say that, contrary to some reports, they are not running into serious problems in inducing employees to accept relocation.

To some extent, they believe, this may reflect the basic nature of the chemical industry: that employees often have to relocate to rise in their company's ranks. Employees understand that, explains one personnel manager, and so they accept the possibility of a relocation when they enter the industry.

But that's not to say that certain kinds of relocations may not be resisted by employees. The Merrill Lynch study, for instance, found that 56% of the 39 chemical and plastics companies surveyed reported that they have had difficulties in getting employees to accept a transfer into an area with a high cost of living. That reason, for one, was cited by Union Carbide for its decision to move its headquarters out of New York City.

Companies also report that employees are asking more questions about the life style aspects of the move—the community, the environment, and so on—rather than just about the monetary aspects. That's a healthier, more realistic situation than blind acceptance of a move, executives say.

When an employee declines a relocation, that also can benefit the company, in terms of preserving continuity within a business unit and strengthening corporate loyalties. That's particularly true, corporate officials believe, as policies change so that an employee can turn down a relocation knowing that it won't finish his or her career on the spot.

The phenomenon of the dual-paycheck family is just starting to be felt in a major way in the chemical industry. In the Merrill Lynch study, for example, 76% of the chemical and plastics companies surveyed did not offer job-finding assistance for working spouses, and only 24% did. Much of that "no assistance" means no hard assistance—actually contacting other companies to find potential openings, or offering the spouse a job with the company itself. More commonly, companies will refer spouses to employment counselors or agencies. And if the spouse also is employed by the company wanting to relocate an employee, it generally will work out a second transfer for the spouse, according to many of the industry's human resource managers.

Collie: chemical companies enlightened

To some extent, it's a matter of the working level of the spouse. Some companies, in fact, draw a distinction between "dual paycheck" family and "dual career" family. The dual paycheck couple, for whom the second check primarily is an extra source of income rather than a professional or career expression, usually is accommodated fairly easily, personnel officials say. It is the dual career couple that can pose problems in a couple's transfer flexibility. Secretarial skills, for example, generally are more easily transferable than those of, say, a product manager or research project leader.

Regardless of that distinction, the phenomenon exists and is growing: Some 24.5 million married women are working or seeking employment, and that number is expected to increase through this decade, with dual earners—as the Bureau of Labor Statistics calls them—becoming by far the rule.

Companies have been making substantial additions to their relocation policies to sweeten the deal for employees, and they are not satisfied with the present status quo. According to the Merrill Lynch study, 28% of the chemical and plastics companies surveyed anticipate making changes in their policies this year, with another 8% undecided. Although the overall business average is 27% of companies that plan to make some changes, to a great extent that depends upon how many people a company transfers; 63% of the companies in the whole study that transfer 500 people or more said they would be making policy changes this year, as did 38 to 39% of the firms that transfer 100 to 499 employees.

The 11 chemical companies planning policy changes cited such changes as developing or increasing a mortgage interest differential allowance (40%), developing or increasing miscellaneous expense allowances (20%), and developing or increasing temporary living allowances and mortgage assistance programs (each 10%). Another 10% are considering covering more employees or new hires.

For new hires, that prospect will be particularly welcome, because the benefits offered them are decidedly less than those for employees. Both

Chemical, plastics firms outpace others in transfers

Number of employees transferred[a]	% of chemicals and plastics firms reporting	% of companies in all business
None	—	1%
1–24	32%	33
25–49	8	16
50–99	16	15
100–249	35	20
250–499	—	8
500 or more	8	6

[a] Average number of employees transferred per company was 146 for chemicals and plastics, down 10% from 1980, and 140 for all business, up 2% from 1980. **Source:** Merrill Lynch Relocation Management

Expenses to relocate employee top $30,000

Selling the house	$ 11,000
Payment of mortgage interest differential	10,000
Shipping goods to new location	3,000
New-home purchase closing costs	2,500
House-hunting trips	2,000
En route and temporary living expenses	1,000
Miscellaneous allowances[a]	2,500
TOTAL	$ 32,000

[a] For example, for recutting of drapes, new license fees, etc. Usually one half to one month's salary. **Source:** Employee Relocation Council

Carbide's mammoth task in moving headquarters

If the average chemical company transfers 200 employees each year, then Union Carbide has packed nearly six years of experience into the past two years. It transferred about 97% of its employees from its Manhattan and Tarrytown, N.Y., offices to new corporate headquarters in Danbury, Conn., with the first job moves in July 1980 and the last batch this spring.

For the numbers involved—more than 3000—it was an exercise akin to an army mapping out battle plans. When the new headquarters were first announced in May 1977, Carbide's employee-relations people went to work. First item on the agenda: Decide whether to do the job in-house, or to work with an outside consultant with expertise built up in the field.

"We decided to do the latter," recalls Ernest F. Schulz, manager of the headquarters assistance program at Carbide. Moran, Stahl & Boyer was selected, and it helped prepare and conduct a survey for all employees. As one indication of the potential significance of the move, the department got back close to 90% response.

"That survey told us where our employees were coming from, and what their needs were," says Schulz. "We were able to integrate that into our program." The company published an official booklet on the program that went through two editions, with subsequent revisions later on.

As a Manhattan-based company, Carbide had a substantial proportion of urbanites among its employees. That posed special problems. For example, Schulz says, "We recognized that there was a large number of employees who didn't know how to drive. So we included a driver-training plan," reimbursing tuition for the employee and for one other household member. Additionally, many of the employees had subsidized or rent-controlled housing, or lived with parents—low shelter costs that would be lost. "So we adopted a renter-to-renter program, and piggybacked onto that, a renter-to-home-owner allowance," Schulz says, with rent-increase and home-buying down payment assistance.

Since the relocation benefits were being offered to all salaried employees, from the chairman of the board to the entry-level clerk, the company surmised that in nonprofessional ranks, in particular, there might be little experience with relocation. So Carbide worked with Moran, Stahl & Boyer subsidiary Area Consultants Inc. to counsel employees and spouses on the move.

In general, Carbide provided assistance with the selling of homes, working with a third-party home-buying company, Merrill Lynch Relocation Management. It paid for the costs of selling the house, moving household belongings, including packing and unpacking. It reimbursed fees for the new residence, including realty fees and those for engineers' inspections. It agreed to pay mortgage differentials for five years. And, to round things out, it paid an allowance for miscellaneous expenses, one month's salary up to $3000.

Out of a total of 3200 jobs in the New York area, the company transferred 3100. Two thirds of the employees lived within commuting range of Danbury, but another 1100 actually were relocated. Schulz won't divulge how much the move cost—that's proprietary information, he says. But he notes that because most of the relocations were made over a relatively short geographical distance, and employees were able to plan with flexibility—anytime between May 1978 and May 1984—the average cost was substantially lower than the industry average of $30,000 to $35,000 per employee.

The entire operation, Schulz says, "went extremely well." He admits to a certain amount of prejudice, because he was in charge of developing it and putting it into effect. But, he adds, "The success is obvious from the high retention rate we had." Would he want to do it again? "Sure, anytime," he says airily—and then laughs.

the Merrill Lynch study and one conducted earlier this year by Russell Reynolds Associates, an international executive recruiting firm, have explored some of the differences.

The Russell Reynolds study looked at the obstacles facing a sample of 180 businesses seeking senior executives—defined as those earning $50,000 or more per year. Some 45% of the chief executives polled replied that it was "much more difficult" to induce prospective senior executives to relocate geographically. Another 42% said it was "somewhat more difficult," and only 11% saw no change. High mortgage rates were the major stumbling block. The next most frequently cited obstacle was difficulty in selling a present residence. Despite that, although 61% said that relocation problems had had some effect on recruitment procedures, only 16% of the companies surveyed said they had made a major effort to recruit locally.

To attract potential candidates, Russell Reynolds found, companies often offer such benefits as payment of temporary or duplicate living expenses (81%), payment of home sale expenses (72%), subsidized mortgages (59%), and engagement of a relocation assistance firm (46%).

On a general level, however, benefits such as those for incoming recruits are less common, according to the Merrill Lynch study, than for a company's current employees. In fact, of the 39 chemical companies in the Merrill Lynch study, only 24 said they provide such assistance for new professional hires. Of those 24, 75% reimburse the hires for some or all of the home sale expenses, and only 50% reimburse for the cost of disposing of a rented apartment. Some 96% reimburse the new professional hire for one or more house-hunting trips, for shipment of household goods, and for transportation of the family to a new location. But only 54% offer reimbursement for some or all of the closing costs on new homes.

The picture is somewhat brighter for new college graduate hires; 30 of the 39 chemical companies sampled provide relocation assistance. But that picture is more spotted. Only 90% of the companies, for example, provide one or more house-hunting trips and transportation of the family to a new location; 93% reimburse for shipment of household goods. Only 40% of the companies reimburse the new college-grad hires for any home sale expenses.

In the long run, however, whether companies match for new recruits the relocation benefits they pay for present employees, the trend is clear: With the average cost of a move hovering around $35,000, companies will be making benefits available to fewer people. Re-evaluation of the need to relocate also will reflect the increasingly expensive time an employee being relocated is out of full productivity—at least for several months and possibly for up to a year as the employee is preoccupied with the idea and then the nitty-gritty details of the move, and the emotional highs and lows of post-move transition. Such re-evaluation should be of benefit to both the company and the employee. □

Chemical & Engineering NEWS

Stanford president Donald Kennedy examines future university research policy Page 35

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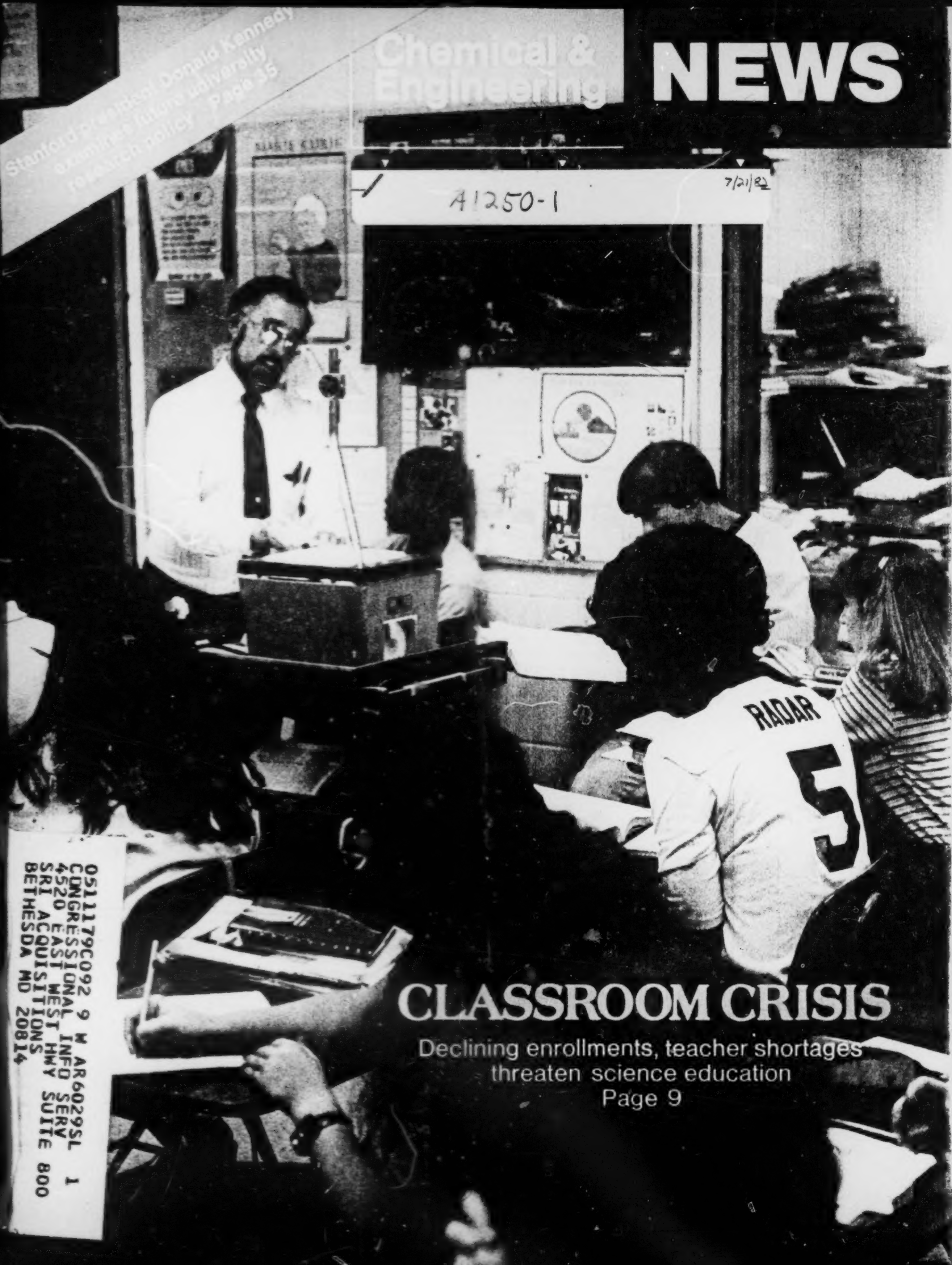

CLASSROOM CRISIS

Declining enrollments, teacher shortages threaten science education
Page 9

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Chemical & Engineering NEWS

Cover: Teacher Douglas Halstead conducts chemistry class at Evanston Township (Ill.) High School. Photo by C&EN's Ward Worthy

4 Letters
5 Editor's Page

Concentrates

19 Business
28 Government
33 Science/Technology

The Departments

48 ACS Comment
50 Awards
60 Newscripts

News of the Week

- ***Love Canal found suitable for habitation;*** *EPA releases results of massive environmental monitoring study.* ***Page 6***
- ***ICI faces possible shutdown*** *of an extensive petrochemicals complex as a result of U.K. tax proposal.* ***Page 6***
- ***Polyolefins business may improve*** *if plant operating rates are high enough to spark earnings improvements.* ***Page 7***
- ***Soviet Union depends more on imports*** *and is less self-sufficient economically than previously thought.* ***Page 8***
- ***Federal waste control system falls into place*** *as EPA issues final standards for land disposal facilities.* ***Page 8***

News Focus

- ***Crisis in science and math education*** *is full-blown; teacher shortages worsen even as fewer students take courses.* ***Page 9***

Business

- ***Key industrial gases fight lower demand*** *as plant construction continues.* ***Page 20***
- ***Clear plastics*** *push up market penetration but further growth is doubtful.* ***Page 24***

International

- ***Chemical business in Western Europe*** *is not likely to pick up this year.* ***Page 25***

Government

- ***EPA-funded test burns of PCBs*** *aimed at establishing a data base.* ***Page 29***
- ***Systematic sequence of testing*** *for food safety recommended.* ***Page 31***

Science

- ***Peptide containing 10 amino acids acts as a neurotransmitter*** *in frog nerve cells, researchers at UCSF discover.* ***Page 34***

Science Policy

- ***Donald Kennedy,*** *president of Stanford University and former FDA head, discusses future academic research policy.* ***Page 35***

Technology

- ***Methanol may free electrical utilities*** *from dependence on oil and gas.* ***Page 41***

Books

- ***"Blaming Technology: The Irrational Search for Scapegoats"*** *sees widespread suspicion of technology, engineers.* ***Page 45***

ACS News

- ***Prices set for CAS publications*** *and microform services in 1983.* ***Page 49***
- ***Patent office evaluates CAS Online*** *system for use in patent examining.* ***Page 49***

In an unusual move to halt what it considers a one-sided feedstock cost advantage, ICI has begun legal action against the U.K. government. The flap has been sparked by clause 129 of the government's Finance Bill now nearing the final stage of its passage through Parliament.

The clause would tax North Sea-derived ethane for ethylene production by BP Chemicals, Esso Chemicals, and Shell Chemical U.K. on the basis of a low "internal" transfer price of the gas set by their oil company parents. The net result, ICI executives claim, is that the ethylene ICI makes by cracking naphtha would be more costly than ethylene made by the others.

There's an irony to the development. Not so long ago, ICI was linked with BP, Esso (Exxon's U.K. subsidiary), and Shell in exhorting the British government to limit North Sea gas availability to established U.K. olefins producers—themselves—and not make it available to others, such as Dow Chemical, which expressed an interest in entering the picture. BP Chemicals currently is planning to convert its cracking operations at Grangemouth, Scotland, to ethane feedstock. Esso and Shell are pushing ahead jointly with an ethane cracker at Mossmorran, also in Scotland. When on stream in about three years, it will have an annual ethylene output capability of 1.1 billion lb.

If ICI wins its case, the economics on which BP Chemicals, Esso, and Shell have based their plans will be thrown into serious question. For their part, on the other hand, ICI managers say they aren't bluffing, and that they will close down Wilton if judgment goes against them. Union leaders believe the claim and already have voiced concern about the impact this would have on the country's already severe unemployment situation. □

Surprise early pickup forecast for polyolefins

U.S. polyolefins—the most important plastics—may not really be the basket case that producers have been saying they are. Indeed, actual plant operating rates may be high enough to spark a significant early improvement in earnings for manufacturers, possibly within a year, according to a controversial new forecast by Oppenheimer, a New York City-based securities firm.

Says Richard A. Derbes, a securities analyst with Oppenheimer, "We believe that supply/demand for the olefin plastics [low- and high-density polyethylene and polypropylene] is not a disaster, because there has been a significant shrinking of capacity over the past year." He adds, in a new report on the plastics industry, "The implication is that operating rates are much higher than is generally perceived, and, as a result, we believe pricing and margins will improve over the next year."

The Oppenheimer report also covers polyvinyl chloride, polystyrene, and acrylonitrile-butadiene-styrene, all of which Derbes is pessimistic about because of depressed demand and low operating rates. But he says that if one subtracts capacity temporarily shut down, effective operating rates are substantially higher than the industry has been assuming.

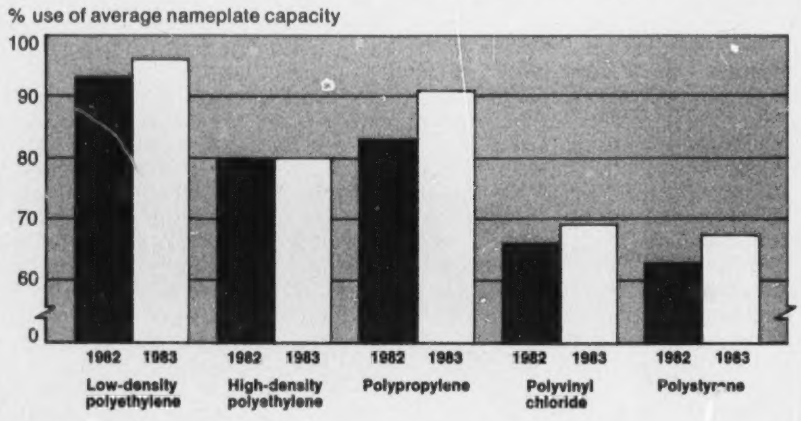
That is particularly the case with LDPE, according to Derbes, who thinks that "a major change has begun to evolve in the LDPE business." Among his arguments are that operating rates for LDPE are 85 to 90% on a nameplate basis and above 90% on an effective basis; nameplate capacity is presently close to 9.5 billion lb per year, and if the pricing situation does not improve in the third quarter, capacity could shrink as much as another 1 billion lb; demand will be up in 1982 because severe inventory liquidation in the second half of 1981 pushed production below consumption; and production may hit 8.5 billion lb in 1982.

Derbes believes that linear LDPE produced by Union Carbide's low-cost, low-pressure Unipol process already is beginning to make older, high-pressure process plants obsolete. That is particularly true, he says, as producers lose the advantage of low-priced ethylene or natural-gas-liquids feedstock. That will result in producers' finally deciding to shut down permanently capacity now mothballed or closed down for temporary maintenance. And that, in turn, according to Derbes, will strengthen polyethylene prices reasonably soon. In fact, he believes that pricing and profit margin improvement on polyethylene will be significant enough to prove a nice boost to producer earnings. He cites Dow Chemical and Union Carbide, in particular, as benefiting from an improvement in the polyethylene business, with their new Dowlex and Unipol processes.

Industry observers are intrigued by Derbes' pared-down capacity figures. But they part company over his predictions on production for the year. The prediction of 8.5 billion lb of production for LDPE, for example, seems quite high compared with an annualized 7.39 billion lb production rate through May using statistics from the Society of the Plastics Industry's Committee on Resin Statistics. Industry sources point out, in addition, that production tends to fall off in the third and fourth quarters. Some pessimists in the industry doubt that LDPE production will top 7.2 billion lb this year.

However, even with LDPE production at this annualized early rate, effective capacity use works out to an 87% rate—not bad for an industry that has been filled with gloom and doom for the past year or so. □

Plant use will be fairly high for polyolefins in 1982 and 1983



Source: Oppenheimer & Co.

Classroom crisis in science and math

Fewer precollege students are opting for science and math courses, resulting in growing public ignorance of technology; meanwhile a shortage of science and math teachers is worsening

Ward Worthy
C&EN, Chicago

For a problem to become a crisis, its time has to arrive. First come the scattered warnings of impending trouble from those closest to it. At that early stage, nothing much else happens. As the problem gets worse, the screaming gets louder—loud enough to gain the notice of people who, although not actually at the scene, nevertheless have an interest in the matter. Finally, if the problem gets bad enough and if the complainers are persuasive and persistent enough, it draws the attention of politicians and journalists. Then it's a crisis.

By that perhaps too cynical definition, a pair of long-brewing problems in U.S. education recently have achieved bona fide crisis status. One problem is that the public, by most objective measures, is becoming increasingly ignorant of things mathematical, scientific, and technological. The other, related to the first problem but distinguishable from it, is a current and worsening shortage of persons competent and willing to teach those subjects to students in elementary and secondary schools. For purposes of convenience, the two have been lumped into one official crisis, the crisis in precollege education in science and mathematics.

Convincing evidence of crisis status comes from a recent National Academy of Sciences (NAS) convocation on the subject in Washington, D.C. (C&EN, May 24, page 39). It was no gathering of deputies, administrative aides, assistant professors, and other lower-echelon people. Real stars were there, including Congressmen, Cabinet secretaries, key bureaucrats, and prominent scientists, educators, and businessmen. President Reagan didn't attend, but he sent a message.

The participants at the convocation all agreed that there indeed was a crisis. They didn't all agree on what should be done about it; in particular, they expressed deep philosophical differences as to who should pay for what. They all did agree that something had to be done, and they arrived at a reluctant consensus that dealing with the crisis will require concerted efforts by government at all levels, colleges and universities, local schools, professional organizations, and private enterprise.

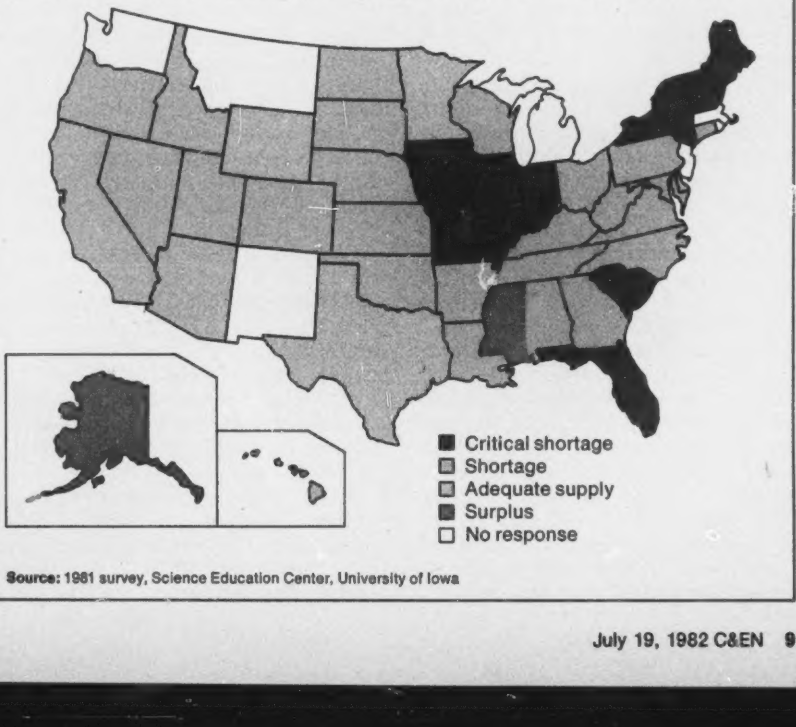
NEWS ANALYSIS

In fact, efforts to alleviate the precollege science/math crisis have begun already, although so far they aren't very concerted. If the taxpaying public also can be convinced of the need for action and financial support—not easy, in the current U.S. economic and political climate—they may succeed. It's to be hoped that these efforts will aim not just at quick fixes but also at grubbing out the roots of the problems. After all, the U.S. went through all this before, in the "post-Sputnik era" of the late 1950s and 1960s, yet here it is again. Or did it ever really go away?

One can argue about that, probably to little avail. However, any "friend of science," regardless of political or educational philosophy, can only be dismayed by the present overall state of science and mathematics education in U.S. elementary, intermediate, and high schools.

For one thing, students are taking fewer courses in mathematics and science than they did formerly. At the NAS convocation, Paul DeHart Hurd, professor of education (emeritus) at Stanford University, presented statistics, gleaned from a variety of sources, to make that point. Currently, for example, only 34% of U.S. high school graduates have completed three years of mathemat-

Most states are short on high school chemistry teachers



Source: 1981 survey, Science Education Center, University of Iowa ics; of those, only 8% have taken calculus, which is taught in only 31% of U.S. high schools. Fewer than 20% of the graduates have had three years of science. Most seniors have had a course in biology and 37% have had chemistry, but only 19% have had physics.

For students pursuing academic courses—about 40% of the total—the numbers are, not surprisingly, higher: 55% have had three or more years of math and 41% have had three or more years of science. But of the other 60% who pursue general or vocational curricula, only 20% have had three years of math and hardly 10% have had three years of science.

Another study reveals that about 48% of U.S. high school students were enrolled in at least one science class in the school year 1976–77. In contrast, the figure was 59% (the highest ever) in 1960–61.

One problem with educational statistics is that there are a lot of them, and they don't always agree. Although the cited surveys describe high school math education, others suggest that high school students are again taking more math. For example, according to the National Center for Educational Statistics, the mean number of semester hours of math taken by high school seniors increased from 3.6 in 1972 to 4.1 in 1980, a 14% increase.

The Conference Board of the Mathematical Sciences notes that from 1975 to 1980 college-level math enrollments increased 33%, even as total enrollments grew only 7%. The board attributes some of that increase to the greater number of engineering and computer science students. However, much of the growth can be accounted for by remedial math courses, in which enrollments increased 70% in the 1975–80 period.

Some observers say that the quality of high school science and math education also has declined. For example, much is made of the fact that mean scores in mathematics on the Scholastic Achievement Test (SAT) declined from 502 in 1963 to 466 in 1980. Between 1967 and 1975, the proportion of students scoring more than 700 points (out of a possible 800) on the SAT math test dropped 15%; the proportion scoring fewer than 300 points increased 38%. Also, national assessments of science achievement—made in 1969–70, 1972–73, and 1976–77 and dealing with nine-, 13-, and 17-year-old students—showed continuing declines, especially for the 17-year-olds and for the physical sciences.

What such measures really say about the "quality" of science and math education is debatable. If fewer students receive instruction in science and math, it seems only natural that across-the-board test scores will go down. Although mean scores are declining, the "top" students seem to be getting better. Between 1969 and 1979, the number taking advanced placement examinations more than doubled, and mean grades moved upward steadily.

Whether more students should take more science and math is a value judgment. To most scientists and mathematicians, and to those that fear incipient scientific illiteracy of the masses, the answer is obvious: They should. That view isn't held universally, however. Unless the entire U.S. education system were made over radically, more science and math would mean less of something else. Other educational constituencies will defend their territories vigorously, and science/math proponents are underrepresented among the people who make educational decisions for elementary and secondary schools. A good "selling job" by these science/math proponents will be essential to gain more ground.

Although there's room for debate about how much science/math education is enough, or about how good it should be, there's hardly any argument that the science and mathematics substructures of U.S. elementary and secondary education are crumbling. Sarah E. Klein, an eighth-grade general science teacher and the retiring president of the National Science Teachers Association (NSTA), described the situation in recent testimony to the science, mathematics, and technology subcommittee of the National Commission on Excellence in Education.

Klein cited, for example, a 1981 survey of state science supervisors by Trevor G. Howe and Jack A. Gerlovich of the University of Iowa's Science Education Center. That survey, based on response from 43 states, disclosed a "critical shortage" of chemistry teachers in 10 states and a "shortage" in 27. For physics and math teachers, the situation was even worse. And for most other sciences, supply and demand were more or less in balance, at least in body-count terms, although there was a slight surplus of biology teachers.

Also, NSTA surveyed colleges and universities with teacher training programs. The results, Klein says, were "shocking." In 1971, the average such institution turned out about 22.5 new math teachers and 18.5 new science teachers. By 1980, the figures had dropped to about 4.9 math teachers and 6.5 science teachers—declines of about 78% and 64%, respectively. And, although numbers are lacking, it's reasonable to assume that many of the graduates didn't end up in teaching jobs.

Another NSTA survey, of secondary school principals, indicated that more than half the newly employed science and math teachers were unqualified to teach their subjects, at least according to the laws and regulations that spell out qualifications. They had been hired on an emergency basis because no qualified teachers could be found.

The same survey showed that in 1981 five times as many science and math teachers left the schools to take nonteaching jobs than left to retire. It also showed that the average science/math teacher was 41, with an average teaching experience of 16 years. Thus, the numbers suggest that high school science and math teachers are an aging group.

As to the quality of science and math education, other numbers give some hints. According to Klein, 60% of the science teachers face cuts in budgets for supplies and equipment, even though laboratory facilities already are obsolete. About 40% of the teachers never have attended a course or workshop since they began teaching. Among elementary school teachers, 51% say their undergraduate training gave them no preparation to teach science, 71% have never had in-service training in science, and 64% had no science consultants assigned to their schools.

How did U.S. precollege science education get in such a fix? It's popular, if not necessarily accurate, to blame most of the problem on the federal government and, in particular, the National Science Foundation (NSF). According to NSTA's Klein, for example, "There is, among those in the Administration, and among many others, the mistaken belief that science education has received substantial support, especially in recent years, and that since we now see all these serious problems, the infusion of massive federal support has been a failure."

Instead, Klein contends, "NSF support for science and engineering education has been declining steadily and steeply for the past 22 years." Science education's share of the total NSF budget dropped from a high of 47% in 1959 to a current low of 2%. Support for precollege science edu-

International comparison: how appropriate?

In the course of discussions about how much and what kind of science and mathematics education American students should receive, comparisons frequently are made between the way it's done in the U.S. and the way it's done in other countries (C&EN, Jan. 25, page 42). Comparisons of the U.S. system with the systems in such countries as the U.S.S.R., East Germany, China, and Japan seem to be particularly frequent.

Here, with no attempts at attribution or confirmation, is a representative sampling of recent pronouncements along that line:

- The school year averages 240 days; little time is lost in absences. The U.S. average is 180 days, with an average of 20 absences per student. The school week is five and a half or six days; in the U.S., almost uniformly five. The school day is six to eight hours; in the U.S., four or five. School vacations are short and dispersed through the year, to minimize interfering with the learning sequence. In the U.S., students take a three-month intellectual vacation every summer.
- Instruction in science and mathematics begins in primary school. Specially trained science and math teachers take over these subjects beginning in the fourth grade. Specialized study begins in the sixth grade. Biology, chemistry, physics, and earth science are required of all students, as are a full complement of math courses. Students spend three times as many classroom hours on these subjects as do U.S. students electing four years each of science and math.
- Students take three or four science courses each term, continuing over several years. This makes it possible to match subject matter to maturity levels and also promotes integrative activities between disciplines. General U.S. practice is to present scientific disciplines in discrete packages.
- Despite the emphasis on science and math, there's no slighting of social studies, the humanities, or foreign languages. Students take nine or 10 courses a year.
- English is regarded as the language of science. Currently there are more students and adults learning English in China than there are English-speaking people in the U.S.
- There seems to be none of the fear of science and mathematics among Japanese school children that is often found, particularly in girls, in the U.S.
- In the U.S.S.R., children study geometry for 10 years, compared with a one-year course, if that, in the U.S.
- In the communist countries test results are not interpreted in a competitive sense as to who has done well or poorly, but rather whether a student has mastered the prescribed subject matter. If test results are below expectancy, the student is tutored by the teacher and other students. The objective is to avoid failure.
- One striking difference between Soviet science education and that in the U.S. is the scientific credentials of people who prepare the curriculum that is used. Several internationally renowned research scientists and mathematicians spend a significant part of their time preparing textbooks for elementary and secondary schools.
- In these countries there is more parental concern, involvement, and responsibility for children's learning than is apparent in the majority of American families.

Enough already. Certainly the U.S. can learn from other countries. And anyone who has spent a day in a U.S. public school can testify that a fair amount of loafing goes on there. Nevertheless, statements like the above, delivered to buttress an argument, invite a certain amount of skepticism. They should be viewed in the same light as recent pronouncements of freedom of religion in the U.S.S.R. It's likely that, in those countries as here, the reality doesn't measure up to the ideal.

Is it merely coincidence that the favorite countries for such comparisons are countries with totalitarian governments or, as in the case of Japan, a nominally democratic government but with a long national tradition of conformity and submission to authority? Maybe not. Those are traits greatly admired in students by many educators. However, they aren't necessarily the traditions that made this nation great.

cation dropped even more sharply, from 72% of the science education budget in 1959 to 22% in 1980. "In terms of the total NSF budget, the precollege share has dropped from 34% in 1959 to its present low of less than 1%."

Much of the decrease in NSF support of science education has resulted from criticisms of curriculum development activities, Klein says. According to the critics, the "new" curricula purged application, concentrated heavily on pure science, and appealed mainly to the brightest students. Similar complaints have been made about "new math" programs. The new programs were "too hard," and thus contributed to the reductions in numbers of students taking science and math courses.

According to Klein, however, a recent NSF study suggests that "the new curricula were far more successful than most people realized." That study, which analyzed 105 other studies involving 45,000 students, compared students enrolled in new science curricula with students enrolled in more traditional programs.

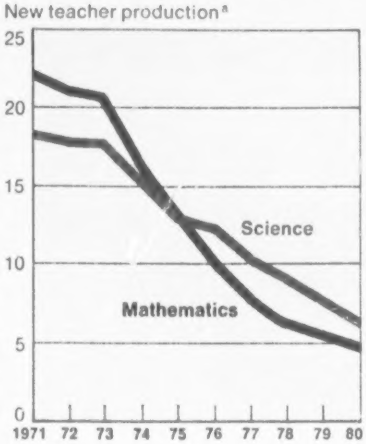
"On every kind of measure, including achievement, attitude, and process skills, students taking the new NSF curricula scored overall 13% higher," Klein says. In the cases of the "BSCS Biology" and "Chem Study" curricula, scores were more than 17% higher. "What is most significant," she adds, "is the fact that students from low socioeconomic groups scored 24% higher using new NSF-supported curricula than traditional curricula."

Klein notes that those studies covered a period of several years in the 1960s and 1970s. Now, she says, few teachers qualified to teach such curricula remain in the schools, "and essentially none have been given the in-service training to do so since NSF abandoned that kind of program several years ago." And by now, Klein adds, "the materials are badly in need of revision and modification to take into account computers, modern electronics, and applications to technology."

Although NSF has taken a lot of flak about its current lack of support of precollege education, the fact remains that it must make do with what it gets from Congress. The agency has responsibilities in many areas of science, of which precollege education is only one. It must set priorities. It certainly isn't solely responsible for precollege science education in the U.S. By cutting off its precollege support almost completely—by bringing the matter to a head, so to speak—NSF rather dramatically has focused attention on a serious national problem. The foundation may have done the country a useful service thereby.

It's also popular to blame the reputed debacle in precollege science education on the science teachers

Output of new teachers fell sharply during the 1970s



[a] Average numbers (per institution) of secondary school science and mathematics teachers produced in teacher training programs at U.S. colleges and universities. **Source**: 1981 survey, National Science Teachers Association

themselves. No doubt they deserve part of the blame. Science teachers, like their students, are a mixed lot: some wonderful, some terrible, most somewhere in the middle. On the whole, however, science teachers are victims of a bum rap, according to Robert B. Sigda. Sigda is an earth science teacher at a suburban junior high school. He also is the president-elect of NSTA. He also was, as he put it, the "token" precollege science teacher at the recent NAS convocation.

In his remarks to the NAS group, Sigda noted that successful learning ultimately depends on the classroom teacher. But the teacher can't do it alone. "Successful science teaching today is a complex interaction of student and teacher involvements with the program, classroom, home, and the national community," he says.

Currently, Sigda goes on, science teachers are facing an identity crisis. "Constantly under attack and blamed for all the nation's ills, teachers, especially science teachers, need a tremendous revitalization of spirit. The attacks are demoralizing to teachers who are trying hard to do a good professional job." When the teachers try to defend themselves against these attacks, Sigda adds, they are accused of being "defensive."

"With the present explosion of scientific knowledge and technology, one would expect science teachers to be filled with enthusiasm," Sigda says. Instead, they are deeply frustrated, because they are criticized constantly for a situation they have no power to cure. "They have the prescription but not the medicine."

Much of the problem is, of course, caused by lack of funds. "Herein lies the ultimate frustration," Sigda says. "The recent suggestions by some that all the funding for science education must come from the local level is totally unrealistic to science teachers who, for many years, have been trying to obtain money from these sources. Anyone familiar with the problems and pressures on local school boards knows that little, if any, funding will come from this source."

The answer isn't simply more federal money, however. In addition, "attitudinal assistance on the national level is needed if our nation's science programs are again to attain the position of eminence they once held," Sigda says. Probably most demoralizing to science teachers in that respect, he adds, is "the constant comparison made between science education in this country and science education in countries such as Japan and the U.S.S.R. It is the science teacher who is criticized when these other countries report that every student in their schools takes chemistry and physics, whereas in this country only 37% of the students take chemistry and fewer than 20% take physics. The major difference between the two systems is rarely reported, however. In the U.S., students *elect* science courses; in those other countries, students are *required* to take science courses."

Sigda's prescription for that particular condition is for the U.S. to follow the example of the authoritarian nations: "The only sure long-term solution to the problem is for the states, who set requirements, to make science education mandatory for every student in this country, from kindergarten through 12th grade."

It might not be that simple. Making something mandatory doesn't mean that it will happen, or that results will measure up to expectations. Reading, writing, and mathematics are mandatory in the U.S. primary education system. But, as is well known, these schools continue to turn out sizable numbers of students who, for all practical purposes, can't read, can't write, and can't do sums. Would it be different with science?

Be that as it may, it's likely true that the main reason students don't take more science and math is that they don't have to. On the whole, requirements for high school graduation were eased during the 1970s, as were requirements for admission to colleges and universities. Students perceive, correctly, that science and math courses are harder than some of the alternatives. In the absence of coercion or convincing motivation, many of them simply take the easier way out.

Stanford's Hurd comments, however, that enrollments in school subjects are influenced by students' attitudes as well as by course requirements. Studies have shown that students don't particularly like science courses, he says, and that the dislike is acquired early. By the end of the third grade, according to one study, nearly half the students feel that they wouldn't like to take science (one can wonder how they arrived at that feeling, since, typically, minimal attention is devoted to science in early elementary school). By the eighth grade, only 21% of the students have positive attitudes toward science. That percentage remains about the same through high school. Another study shows that math popularity drops from a high of 48% in the third grade to a low of 18% in the 12th grade.

An encouraging note, Hurd adds, is that most students seem to like science when they learn it outside school—on television, or at museums and planetariums. But in the case of formal science courses, a majority of high school students feel that they are boring, with too many unfamiliar terms and too much emphasis on memorization of apparently unrelated facts, and generally irrelevant to everyday life. Obviously, a sizable minority of students don't feel that way. And "fun" is not a major goal of education. Still, the number of disaffected students is so large that their criticisms of science education oughtn't be dismissed lightly.

On the other hand, science education also may be plagued by too much relevance. When a national problem catches the public's attention, there's often a call to solve it by adding a unit to the science curriculum. "If it's found that young people are eating the wrong foods," NSTA's Sigda says, "a cry is heard for nutrition units to be added on to the science curriculum. Similar calls have been made for units in the areas of drug, alcohol, and sex education, as well as conservation, energy, environmental, and computer education."

Certainly, those are important topics. However, Sigda says, "If more time is to be spent on these issues, then science courses should be redesigned to reflect the addition of this 'new' information and the deletion of other information. Instead, the teacher is usually left to cope with the constant fracturing and disintegration of the science program." Despite all this adding on, Sigda adds, the public's expectation of science education never lessens.

The point is well taken: In that situation, something is bound to suffer. However, if Sigda had his way the kindergarten teacher similarly would be forced to add on a science unit to the kindergarten curriculum. What should be cut? Finger painting? Nap time? Milk break? The decision could prove difficult.

There's a current and growing shortage of precollege science and math teachers—especially of good ones—for much the same reason that fewer high school students are taking chemistry and calculus: Incentive is lacking.

For one thing, the current crop of college students has heard and heeded 1970s predictions of a teacher glut, and fewer are studying to be teachers of any kind. In fact, there is a surplus of people with certain teaching skills, but that hasn't been and isn't now the case for math teachers or for teachers of most sciences. Nevertheless, a lot of good students who could be good science and math teachers are deciding they'd rather be something else for some pretty good reasons.

Why, for instance, should a gifted college chemistry student aim for what is likely to be a dead-end job teaching high school chemistry, in which he or she will spend a good part of the workday doing things like filling out reports and keeping order in the halls, and in which he or she will have to put up with snotty adolescents, bureaucratic administrators, ill-equipped laboratories, and unreasonable expectations—all for $10,000 to $15,000 a year—when, with the same talent and essentially the same amount of effort, that gifted chemistry student could just as easily take a job in industry or government that would pay twice as much and also would offer more chance for advancement, better working conditions, and more respect?

Well, there are reasons, both noble and petty. The long summer vacations are nice. For people who just can't tear themselves away from their home towns, or for husbands or wives who have deferred to their spouses' careers, such teaching jobs may be the best available fulfillment of their own scientific ambitions. And, although there is a tendency for the public to badmouth teacherdom in general, worthy individual teachers are, in fact, usually accorded considerable respect and status, especially in smaller towns where they are visible members of the community.

Klein: shocking drop in teachers

More important, there are still men and women for whom there can be no greater success than the successes sometimes achieved in guiding young people toward enlightenment. There are still people who, as the saying goes, "love to work with kids."

Fortunately, some of these people are also competent chemists—or biologists, or mathematicians, or whatever—so there always will be some good high school science and math teachers. Unfortunately, there won't be nearly enough of them unless things change.

Sigda: victims of a bum rap

The choice of any career is determined by a number of factors, including abilities, connections, opportunities, desires, and dumb luck. In addition, any career must offer rewards (or no one would choose it) and it certainly will demand sacrifices of one sort or another. Individual perceptions of reward and sacrifice vary, but only within limits. Today, it seems, more and more of the people who would make good science or math teachers have concluded that the rewards of such careers can't compensate for the sacrifices. The teaching jobs probably will be filled by somebody. But they are more likely to be filled by the desperate than by the dedicated.

Another factor also may have contributed to the decline in numbers of new science and math teachers: the way the U.S. goes about training them.

In the last half of the 19th century and well beyond the end of World War II, the "normal school" and the "teachers' college" played large roles in U.S. higher education. The goal of these institutions was unambiguous: to educate their students broadly and to train them to be teachers in elementary and secondary schools. Their programs reflected that goal. What their graduates may have lacked in elegance, they made up for in serviceability, and they generally served the country well.

However, utility, like familiarity, often breeds contempt, especially in the academic world. Prestige and grants accrued not to the plebeian teachers' colleges but to the big state universities and to other glamorous research-oriented institutions. So in reactions to this and to an over supply of teachers, teacher training institutions have changed their names and expanded their goals.

In the mythical state of Sorry, for example, what used to be Possum Knob Normal School is now Sorry State University at Possum Knob. SSU at PK pretends it's just like the real Sorry State, only somewhere else.

Whether this development is on balance good or bad is, again, a value judgment. Times change and so do the U.S.'s educational needs. The rechristened schools are, on the whole, better than they used to be. The catch is that hardly any schools now have as their major aim the production of teachers.

Responsibility for production of elementary school teachers and for training of school administrators is assigned fairly clearly to university departments of education. But the responsibility for training teachers to teach specific disciplines in elementary or secondary schools has been left sort of floating around.

With respect to science and math teachers, Stanford's Hurd states the case this way: "The academic preparation of mathematics and science teachers has become an unrecognized responsibility of these departments in colleges and universities. These departments typically do not offer or require the range of background courses needed by teachers to qualify them for teaching nonspecialists. Some of these courses, for example, might be the sociology of modern science, statistical procedures in the behavioral sciences, human ecology, technology achievements, decision making, and general courses which provide a perspective of entire disciplines.

"In terms of professional qualifications," Hurd continues, "science teaching and engineering occupy the same position relative to science. Both are applied fields. Engineers select information from the sciences and mathematics to solve problems. Teachers select information from these same fields to interpret science to nonspecialists."

But, Hurd says, the education that a science teacher now gets "is that of a researcher cut short at the end of four years." Today, Hurd contends, "the training of science and math teachers in universities has become nobody's business."

Or maybe too may people's business, which can amount to the same thing. J. Dudley Herron, chemist and professor of science education at Purdue University, comments that "in Indiana, we have one school of medicine, two schools of engineering, one school of agriculture, and more than 20 schools which sometimes graduate chemistry teachers. Does this really make any sense? I don't think so. The number of medical doctors in Indiana is certainly more than the number of chemistry teachers." Herron is talking about Indiana, of course, but the point of his comment probably is valid for other states as well, and for other scientific disciplines.

Given the modest numbers of new chemistry teachers needed each year, it should be evident that special programs for chemistry teachers can be justified only if the necessary people and resources are concentrated in one or two places in each state, Herron says.

It's been suggested that Herron is in effect arguing for the return of the old normal school. Not so, he counters. Rather, "I would like to see the education of high school chemistry teachers carried out at a major university with a strong research program in chemistry as well as strong credentials in education. Both are needed to provide the expertise and the experiences needed for quality preparation of teachers.

"That institution should be adequately funded to carry out a program of excellence. It should recruit staff who are recognized for their excellence in teaching chemistry. Some of the faculty should be actively engaged in scholarship which is related directly to science teaching. Information gained from this research should be applied in courses for prospective teachers.

"For years we have argued that successful teacher education requires cooperation between professional educators and academic specialists," Herron continues. "But what happens in fact? In fact, it is difficult to get members of the chemistry faculty to sit on the Teacher Education Council. When I chair the Chemistry Certification Committee, other members accept my judgment on virtually every decision and rely on me to provide information and to initiate changes in our program."

Is that because Purdue chemistry professors don't care about chemistry teacher preparation? No, Herron says, it's because Purdue has fewer than 10 people graduating in chemistry education each year, compared to hundreds of agriculture majors, hundreds of engineers, and hundreds of students from other fields who also are taking chemistry.

"It's not callousness but realism that makes a physical chemistry professor more concerned about the 100 engineers in his course than about the four teaching majors," Herron says. It's not lack of concern, but self-preservation, that makes a faculty member prefer taking on undergraduate research students to designing a directed study for a teaching major. "There just isn't any percentage in devoting a large fraction of one's time to the few teaching majors rather than to the many majors in other professional areas," he says.

Nor do things improve after graduation. "A high school chemistry teacher needs graduate courses in chemistry to keep up with developments in the discipline—and to move up the salary schedule," Herron says. Teachers seek such courses during summer vacations. However, college chemistry professors move up their salary schedules "through scholarly achievement in the form of research publications or textbook writing. They try to do that during the summer. What high school teachers need for their advancement and what professors need to be doing for their advancement don't coincide."

Thus, at both undergraduate and graduate levels, the typical university chemistry curriculum ill meets the particular needs of the future chemistry teacher, according to Herron.

When chemistry is taught to future research chemists or is taught as a service course for students entering other technical fields, the primary need, the Purdue chemist-educator says, is to convey the principles of chemistry to them and to help them develop technical skills in applying those principles to problems in their fields. For those students, such things as seeing the applications of the principles to other fields and understanding the experimental evidence from which the principles were derived may be nice to know, but they aren't vital.

That isn't true for high school chemistry teachers, Herron says. Certainly they need to know the principles. But that isn't enough. Chemistry teachers need to know not only what chemists believe about matter but also why they believe it. They need a qualitative understanding of the principles, to be able to show students how a principle applies to a large number of situations in many fields.

Furthermore, it takes more than traditional chemistry courses and traditional education courses to make good chemistry teachers, Herron says. "Although prospective chemistry teachers will surely take education courses in which they will study the general principles of teaching, how those principles can best be applied to the teaching of chemistry isn't self-evident. Prospective teachers need to be exposed to *chemistry* courses in which strategies for developing an understanding of a principle are discussed along with the principle itself." Such courses won't be forthcoming, Herron concludes, unless enough students can be concentrated in one place to justify offering them.

Fortunately, the story can end with a cautiously optimistic note. There are signs that the situation has "bot-

Embassy of Japan photo

Elementary school pupils in Japan conduct experiment on oxygen properties

tomed out" and that the outlook for the future of science and math education in the U.S. is brighter than its recent past.

At the NAS convocation, for example, B. Frank Brown, chairman of the Florida Governor's Commission on Secondary Schools, said that "the state picture, which has been dismal, is now at a turning point. There is new momentum building among the states for increasing competence in science and mathematics. California and Florida, which led the trend to abandon graduation standards, now are leading in the other direction by proposing the enactment of new levels of excellence for graduation from high school."

Brown notes that another Brown, Gov. Edmund G., Jr., of California, in a recent "education initiative," has proposed that local school boards require at least three years of math and two years of science for all students, and more for college-bound students. The Florida commission goes even further, recommending requirements of four years each of science and mathematics for graduation from high school. Similar actions are at least in the planning stages in several other states. Many colleges and universities also are re-examining their entrance criteria, and the trend is toward stiffer science and math requirements.

Although organized teacherdom has a long record of being generally opposed to different pay for different subjects, market forces nevertheless are beginning to have an effect. For example, the Houston Independent School District has instituted a plan that provides for incentive pay to teachers in several categories, including the category "critical staff shortage." In the case of secondary science and math teachers, the stipend comes to $800 yearly.

The Houston plan also provides $400 stipends for professional growth, that is, for taking appropriate courses. Interestingly, courses in general education, administration, counseling, and guidance don't qualify; chemistry courses do. Stipends also may be granted for outstanding performance to teachers whose students do better than achievement goals would predict.

The stipends aren't very large, but every little bit helps. In any case, they're an encouraging sign of change in a field where merit traditionally has run a distant second to seniority.

The argument about the proper federal role in support of U.S. education continues to be noisy and the outcome uncertain. Still, even the most ardent of the "new federalists" seem to admit that the national government can't ignore the problems, and some new federal initiatives are pending.

For example, Sen. John Glenn (D.-Ohio) and Rep. Don Fuqua (D.-Fla.) recently introduced parallel bills in their respective houses that would establish, within NSF, a National Coordinating Council on Engineering & Scientific Manpower. One purpose of the council would be to encourage and promote high-quality precollege science and math education. The bill would set up a fund, initially $50 million a year, to carry out the council's charge.

Also, Sen. Gary Hart (D.-Colo.) and Rep. Carl D. Perkins (D.-Ky.) have introduced bills that would lead to an "American Defense Education Act," with such objectives as increasing national productivity and strengthening national security. These bills include provisions for monetary incentives for local school districts to improve elementary and secondary education in the sciences and mathematics as well as in foreign languages, communications skills, and new technologies.

All these bills are still in early stages of gestation. It's too soon to know what their final form will be, or whether they will pass.

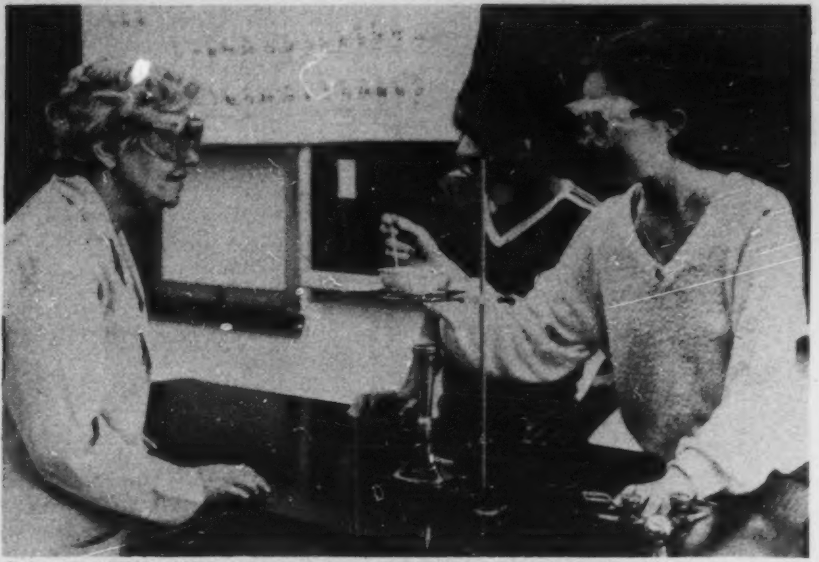
Federal educational assistance programs have been accused of lacking focus and direction. The current Administration denies that it's turning its back on U.S. education problems; rather, it has deliberately suspended what President Reagan calls "a proliferation of small federal programs which—taken together—showed themselves to be ineffective."

To try to provide some focus and direction, the National Science Board (NSF's policy-making body) last year established a Commission on Precollege Education in Science, Mathematics & Technology. The commission, comprising, according to NSF, "18 highly respected individuals from a wide variety of fields," started work in April. Its job, to be done by Oct. 15, 1983, is "to define a national agenda" for improving science and math education and to "develop an action plan that will include a definition of the appropriate roles of federal, state, and local governments, professional and scientific societies, and the private sector in addressing this problem of national dimension."

As noted, many of those entities already have begun to take action without waiting for their roles to be defined.

For example, the American Chemical Society. It probably isn't grossly unfair to say that for a long time the main service that ACS rendered to high school chemistry teachers was lip service. That situation has changed markedly in the past few years, however.

The ACS Division of Chemical Education formed a High School Chemistry Committee in 1978 and gave it the job of "bringing high school chemistry teachers into the mainstream of chemical education activities." The following year, the Office of High School Chemistry was established within the ACS Department of Educational Activities. The two work closely with each other and with ACS local sections.



***Only about 37% of high school students choose the chemistry option** (here being taught by Claire Smith at a San Francisco high school)*

Also within ACS, regional, national, and divisional meetings and conferences have been broadened to include programs specifically aimed at secondary level teachers. The *Journal of Chemical Education* for the past several years has had a section devoted to secondary chemical education articles.

At the local and regional levels, "Expert Demonstrator Training Activity" workshops have been developed to train local section members to perform effective chemical demonstrations and to conduct their own workshops for local high school chemistry teachers.

The ACS Office of High School Chemistry publishes a quarterly newsletter, *Chemunity*, available free to interested high school teachers. It's published a booklet to help local sections organize effective programs to promote chemistry in high schools. It makes available a variety of teacher support and continuing education materials. It coordinates award programs for high school chemistry teachers.

Currently, the office also is coordinating the development of a new interdisciplinary science course for 10th grade students. This course, "Chemistry in the Community" (ChemCom), aims to use chemical concepts for "helping students to understand and to seek solutions for technology-related problems of today." The project is directed by chemical educator W. Thomas Lippincott of the University of Arizona.

ChemCom will consist of 10 modules, with titles such as "Supplying Our Water Needs," "Understanding Nuclear Issues," and "Chemistry in Public and Personal Health." NSF has furnished funds to develop seven of the modules and the ACS Petroleum Research Fund for an eighth module, "Petroleum: Uses, Resources, and Importance for Society." Funds for the other two modules still are being sought.

Other professional and scientific organizations, like the American Association for the Advancement of Science (AAAS), also are showing increased sensitivity to the needs and problems of the secondary school science and math teacher. AAAS, for example, has begun a Teacher Notes project "designed to help bridge the gap between what is happening in the sciences and what is taught in the schools." The notes include suggestions for student activities using easily available and inexpensive materials. Related slides, posters, and computer programs to back up the notes also are planned.

In another project, AAAS, with funds from Phillips Petroleum, will produce "Challenge of the Unknown," a set of supplementary math materials "to help teachers enliven mathematics learning" by students in the middle grades.

In the field of general educational research, considerable recent progress has been made in understanding basic mechanisms of learning—with obvious implications for the teaching of chemistry and other sciences. From some of this research have come suggestions that the way chemistry usually is taught today may have little relationship to the way it's learned (C&EN, April 12, page 35). Not everyone accepts all the findings of this research, but nevertheless it has led to a renewal of interest in research on science teaching as such.

In addition to efforts to improve the quality of science education, there also are efforts to make science more attractive to more students. Some of the ACS activities aimed at precollege students—like Career Days and "Meet a Scientist" nights—are frankly promotional as well as educational.

Also, a good many chemists around the U.S. have taken it upon themselves to present "chemical magic" shows—complete with color changes, chemiluminescence, clock reactions, and explosions—to younger students. At the University of Wisconsin, for instance, Bassam Z. Shakhashiri notes that he and his group have put on "Chemistry Can Be Fun" programs 18 times just this year, for some 5000 junior high students in the Madison area.

Another encouraging note comes from Chicago, where the Regenstein Foundation has donated $1 million to the Museum of Science & Industry for a permanent exhibit on "Everyday Chemistry." A highlight of the exhibit, which is set to open next June, will be a group of 14 chemical reactions and demonstrations, controlled by microprocessors but set in operation by the visitors. "You will note color changes and luminescence, identify organic compounds by smell, and feel the heat released from reactions," a museum spokeswoman notes.

Some chemists look askance at that sort of frivolity. "Chemistry isn't supposed to be fun," they say in effect. "Chemistry is hard work." Well, one can accept the second premise and still dispute the first. In the course of his duties, this reporter has interviewed many distinguished practitioners of chemistry, often in connection with their receipt of some prestigious award. A stock question on such occasions is ,"Why are you a chemist?" Perhaps the most frequent answer is, "Because it's fun." Not noble, or important, or beneficial to humanity, or intellectually challenging (though it may be all those things), but "fun."

The more chemists—and other scientists, and mathematicians—bring themselves to unhypocritical acceptance of that notion, the more successful they will be in winning young students to their cause. □

Industrial gases fighting excess capacity

As the recession bites into demand for oxygen, nitrogen, and carbon dioxide, plant construction continues, worrying some producers

William J. Storck
C&EN, New York

In some ways, 1982 is shaping up as a repeat of 1981 for industrial gas producers, but perhaps worse.

Production of the largest-volume gases is, in most cases, off from last year's levels. Prices are not rising to keep up with cost increases, and many of the announced price increases have not stuck. Some producers seem to be trying to grab market share at the cost of profitability. And excess capacity is overhanging the entire market.

In the first quarter of this year, capacity utilization for industrial gases was running at an average of about 64%, down considerably from 69% in the third quarter last year and about 66% in the first quarter a year ago.

Producers say that profitability is still below reinvestment levels, especially considering the high interest rates that go along with financing new plants.

But, they keep on building. Most producers say they have not cut back on capital plans, but rather are "building for the future." And, they say, many of the new plants will replace older facilities.

Some producers, however, are beginning to become concerned. They say that if the current wave of building continues, there are going to be a lot of shut-down plants—especially air separation facilities for oxygen and nitrogen—in the industry. The situation does not seem to be so bad for carbon dioxide, plants for which are limited by the amount of feedstocks that can be derived as a byproduct from other chemical processes.

And to a certain extent, some plants are shut down right now. But most of the facilities that have been shut down permanently have been replaced by newer, more efficient units.

One of the reasons for building now may be a shift in the geographical nature of the business. Industrial gas producers say they are building more plants in the South and in the Pacific areas as their customers gravitate that way. And they are trying to build in areas where electrical power is less expensive.

Key Chemicals

Unfortunately, these two aims are operating at cross purposes to a certain extent. Although the industrial gas business in the Midwest is in poor shape because of the steel and auto industry slumps, this seems to be the area where producers can get cheaper electrical rates. And the Pacific has some of the highest electrical power rates in the country.

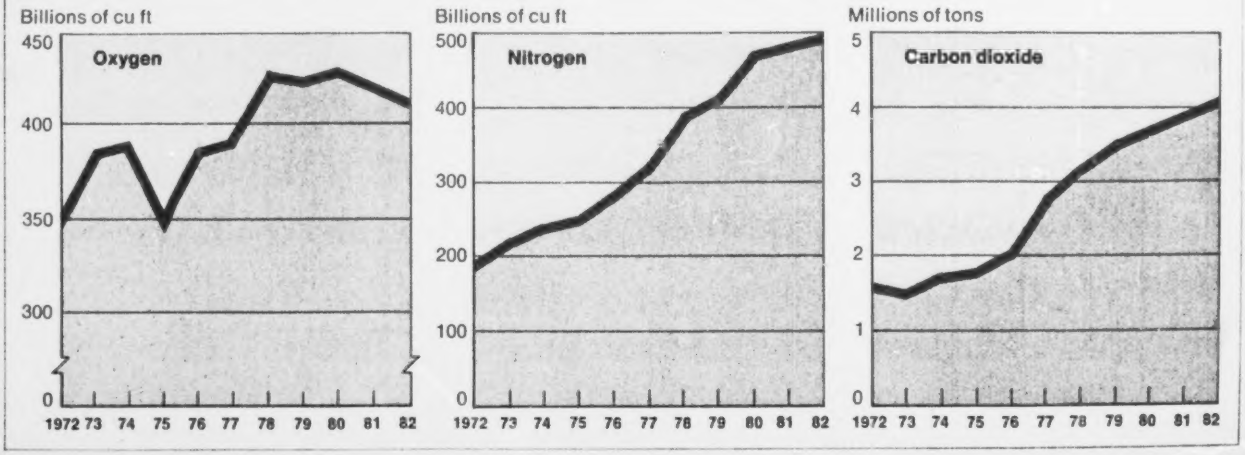
The recession is biting into the industrial gas business in terms of transportation as well as in pricing and demand.

Producers say that the costs of shipping in wages for drivers and for fuel is increasing, but not so fast as it has been in the past.

The recession has hit more than just the three largest-volume gases. Hydrogen also is having a hard time of it this year as its uses in chemical processing and blanketing atmospheres for metals decline. Producers say the hydrogen business is approaching maturity, and they also are finding that it is not so recessionproof as they once thought. Prices for hydrogen have increased only about 1% this year. And there will be only marginal growth, producers indicate. In fact, for the long term, hydrogen makers say that markets probably will grow only about the same as the gross national product.

For a more detailed 12-month outlook for nitrogen, oxygen, and carbon dioxide, see the following pages. □

Carbon dioxide, nitrogen output has grown steadily, but oxygen has slipped



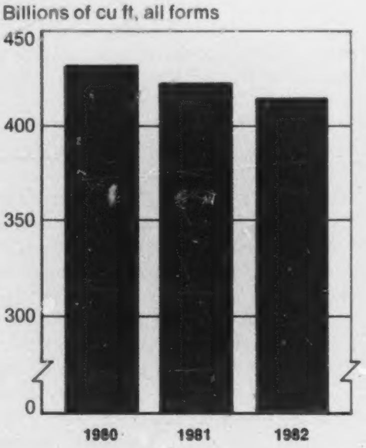
Key Chemicals

O_2

Oxygen

- ***Demand down***
- ***Prices soft***
- ***Margins slipping***

PRODUCTION



HOW MADE

Separated from air at low temperatures

MAJOR USES

Primary metal manufacturing 30%, health services 13%, metal fabricating 33%

FOREIGN TRADE

Negligible

PRICES

41 cents per 100 cu ft plus shipping and equipment charges (merchant)

COMMERCIAL VALUE

$470 million for production, 1982

Oxygen, which used to be the largest-volume industrial gas, has run into so many problems over the past few years that it has slipped to second place behind coproduct nitrogen.

In fact, the two gases exchanged places on C&EN's list of Top 50 chemical products last year, with oxygen falling to fifth place from third, and nitrogen rising to third place in 1981 from fifth place the year before.

It really is no surprise that oxygen has fallen on hard times. It is the most vulnerable of the industrial gases to fluctuations in the economy. Its biggest markets are in highly cyclical industrial markets such as steel and other commodity metals. Thus, when auto production declines, so does steel output and, consequently, demand for oxygen.

One producer says that so far the steel industry is performing almost abysmally. The producer adds that steel production is down about 34% thus far this year, after a pretty good first quarter. He estimates that for June and July, steel production may well be down as much as 50% from last year's levels.

This situation over the past couple of years has led oxygen into a classical recessionary situation with overcapacity on the production side and discounting on the price side.

Overcapacity is something that may well remain with oxygen producers not only through this year, but into 1983 and perhaps 1984 as well. One producer says that even with the current overcapacity, there seems to be very little cancellation of projects currently under construction and slated to come on stream both this year and next. However, new plants coming on stream are replacing some older plants that are not so efficient.

Efficiency of production and productivity are meaningful words to producers these days as energy costs, which are the primary production costs, continue to escalate. Producers note, however, that cost increases in energy have slowed from a year ago.

Still, producers are being squeezed in terms of profitability. Although production costs as well as transportation costs are not increasing so fast as they were, the price that producers are getting is not increasing so fast as costs. Producers say that although they tried to get an 8 to 10% increase last September, they actually are getting about 1 to 2% more for merchant oxygen than they were getting at this time last year, mainly because of discounting. Two reasons are given for discounting. One is that market conditions are such that users of oxygen can stall any price increase. The second reason is that newer entrants into the industrial gas market are trying to compete on price rather than technology. Thus, they are discounting their product in an effort to gain market share. And, with the current—and probably continuing—overcapacity, producers say that pricing problems will be around for a while.

On the tonnage or pipeline side of the business, which is tied more closely to big steel than is merchant oxygen, producers say that, despite take-or-pay contracts, profitability is below reinvestment levels, especially considering current high interest rates.

Oxygen producers claim that for tonnage, as well as for merchant oxygen, the first quarter started out below year-before levels, but in the past few months demand has taken an even sharper turn downward. Through the first quarter, oxygen demand was off 8.8% from first-quarter 1981. April production, however, was down 15% from April 1981.

Producers think that May and June were off even more as steel production has dropped drastically and output of automobiles at the end of June hit its lowest level in more than 20 years.

For the remainder of the year, oxygen producers are not at all hopeful. They say that since practically all of oxygen's markets are down and since the major market is in metals, it will be at least 1983 before there can be any hope at all of a turnaround.

Given the current state of the market, producers may try for yet another price increase later in the year (something they have not done since last September). But, they may not have any more luck with one this year than they did last.

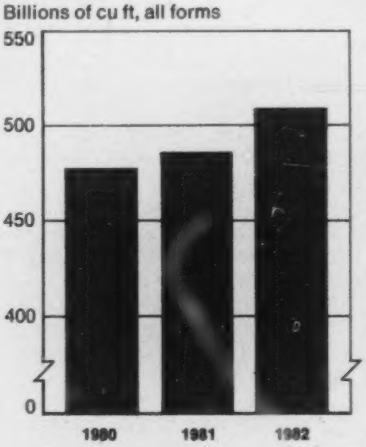
Thus, for the remainder of the year, it looks as if producers are going to continue to suffer the ills they have had for the past year—low capacity use, soft pricing, and increasing costs.

Nitrogen

N_2

- ***Growth slows***
- ***Prices discounted***
- ***Margins shrinking***

PRODUCTION



HOW MADE

Separated from air at low temperatures

MAJOR USES

Blanketing atmospheres—chemical processing 14%, electronics 16%, metals 5%; freezing agents 21%, aerospace 8%

FOREIGN TRADE

Negligible

PRICES

39 cents per 100 cu ft plus shipping and equipment charges

COMMERCIAL VALUE

$430 million for production, 1982

Nitrogen—long the number two industrial gas in terms of volume, but now number one—is not having a particularly good year, according to producers.

For the first four months of 1982, production has fallen to 159 billion cu ft, down 0.5% from the same period in 1981. Coming off only 1.3% growth between 1980 and 1981, this is bad news to nitrogen producers, who are used to bigger numbers than that.

For the past 10 years, according to U.S. government figures, nitrogen production has been growing at more than 11% per year and in 1980, production was up 16% from 1979.

So, in the current recession, what may look fairly good to producers of other large-volume chemicals looks pretty dismal to producers of a product that until just a year and a half ago was growing at a fairly constant high level.

Now that nitrogen has gained the top place among the industrial gases, it probably will stay there. Although it is not doing very well this year, nitrogen has more growth markets than does oxygen, which formerly held the number one slot. In addition, nitrogen's markets are much more diverse than those for oxygen, which is tied largely to commodity metals in one form or another.

Nitrogen, too, has some markets in metals, mainly as a blanketing atmosphere; producers say that demand in this area is down considerably this year. But use in some of its other markets is either up slightly or on hold with producers expecting renewed growth when a turnaround does come.

Food freezing is one market that producers say is performing fairly well this year. They claim that this market is largely countercyclical. During a recession, people either increase their use of frozen foods at home or eat more at fast food outlets, which use food frozen with nitrogen (or carbon dioxide).

Another area showing fairly good growth, although not so fast as in the past, is in oil field use. Producers say that in the past, nitrogen use for enhanced oil recovery had been growing so fast that they have had trouble tracking it. This has slowed considerably in the past year as oil demand has fallen, but they see a pickup in the future.

Oil field use of nitrogen is growing well for both the merchant and tonnage types. Merchant nitrogen (and oxygen) is that sold as gas or liquid in cylinders and tank cars. Tonnage industrial gases are produced at on-site plants and the gas is piped directly to the user.

In oil fields, merchant nitrogen is used under contract in pilot operations usually lasting from one to three years. If the use works out in enhanced recovery, an on-site plant will be built to provide much larger volumes more economically.

Nitrogen, however, is plagued with many of the same problems as other gases—rising costs and fairly flat prices, resulting in shrinking margins.

The cost of electricity, which is the primary production cost for nitrogen producers, has been escalating at more than 10% per year. In addition, labor costs and the cost of transportation have been increasing rapidly. These cost increases have been slowing somewhat this year, producers say, but not enough for the occasional price increases they have been getting to keep pace.

Nitrogen currently is selling to the largest merchant users at an average price of about 39 cents per 100 cu ft. This is up just 1 cent from this time last year, although producers tried to get an 8% increase last September.

And even the 39-cent price may be illusory. Producers say that the discounts on individual deals are such that it is practically impossible now to say what the real price for nitrogen is.

The rising costs—especially electricity—associated with nitrogen also may hurt the refrigeration use of the gas in the long run. Producers say that as the costs and, therefore, prices go up, many refrigeration users may begin to look at other methods such as mechanical refrigeration or carbon dioxide.

For the remainder of 1982, producers do not see that happening, however. What they do see is a moderate increase in demand for the remainder of the year so that nitrogen may finish 1982 with production about 4 to 5% ahead of 1981. Prices probably will go up later in the year, but whether producers will be able to get what they ask or whether it will be a repeat of 1981's much reduced actual price increase is still open to some question. Probably, it will be the latter as demand probably will not pick up enough to persuade users to pay the full price.

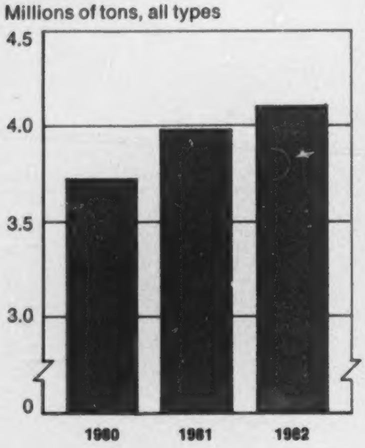
Key Chemicals

CO_2

Carbon dioxide

- ***Demand still up***
- ***Prices higher***
- ***Feedstock tight***

PRODUCTION



HOW MADE

Recovered from synthesis gas in ammonia production, recovered as by-product in substitute natural gas production, recovered from fermentation ethanol production, recovered from natural wells

MAJOR USES

Refrigeration—food 37%, industrial 5%; beverage carbonation 20%; other industrial uses 22%

FOREIGN TRADE

Negligible

PRICES

About $71 per ton for largest users; prices vary by region

COMMERCIAL VALUE

$147 million for production, 1982

Carbon dioxide is doing better this year than either of the other two large-volume industrial gases—nitrogen and oxygen—after performing better than either of them in 1981.

Last year, production of carbon dioxide grew 7% from 1980 to almost 4 million tons. In spite of that, however, it still fell from 18th to 19th place on C&EN's list of Top 50 chemical products.

For the first four months this year, production is running about 3.6% ahead of last year, according to the Bureau of the Census. Output in January through April was about 1.30 million tons, compared to about 1.25 million tons in the same period of 1981.

Output of liquid carbon dioxide, the largest-volume form, however, is down about 1.8% to 920,869 tons in the first four months. Solid carbon dioxide, or dry ice, output is also down, declining 10.7% to 90,709 tons in the first four months of the year. Producers expected this of dry ice, however; its output hasn't grown for a number of years.

The area that has made up for the rather lackluster performance in the other two forms is gaseous carbon dioxide, whose output through the January through April period is up 33.9% to 289,050 tons. Two reasons for its tremendous growth are: There are new customers for it who eventually will upgrade to liquid as their businesses grow, and there has been enough shrinkage of businesses that previously used liquid carbon dioxide that they have returned to the gaseous form. Most of the customers for gaseous carbon dioxide use small quantities of the gas.

The biggest problem that carbon dioxide producers seem to be having is acquiring the carbon dioxide to sell. Most carbon dioxide comes from ammonia plants, which are being hit by a slump in fertilizers. During the first quarter, ammonia plants were operating at about 80% of capacity (C&EN, May 24, page 16). However, this level may well have dropped since then. Carbon dioxide producers say there are plants shut down completely and others that are operating on a sporadic basis. At this time last year, carbon dioxide producers already were complaining about availability of supply, and this year, ammonia production through April was 16% below year-before levels.

Carbon dioxide producers seem to be doing better in pricing than are producers of other industrial gases. Prices of liquid carbon dioxide have increased to about $71 per ton for the largest users from about $64 per ton a year ago. This price varies greatly by region. And producers say that prices are not being discounted, as they are with oxygen and nitrogen, although there is some price cutting.

Food freezing still is the fastest-growing, large-volume use for carbon dioxide, and producers believe it may continue to grow for some time. They see many customers who presently use nitrogen in food freezing switching to carbon dioxide as the costs of producing nitrogen continue to increase. Nitrogen producers, however, say there will be just as much switching to mechanical freezing, if this is the case, as there will be to carbon dioxide.

In the past, both nitrogen and carbon dioxide producers claimed that certain foods freeze better with one or the other of the two gases. Now, however, they pretty much have abandoned that line and say that although some foods may require one or the other of the gases, these types of foods are very few. "Cost is now the major factor," says one carbon dioxide marketer.

The other fast-growing area for carbon dioxide—oil fields—also pits the gas in competition with nitrogen. In this area, producers say they are a little slower off the mark against nitrogen; "There seems to be a bias toward nitrogen which we are finding difficult to counter," one producer says.

For the rest of this year, carbon dioxide well may prove to be the best performer of the gases. Producers see demand for the product growing at about 5 to 6% this year. This is possible if demand holds up through the peak summer season and the oil field uses come back somewhat in the fall to take up the off-season production.

Prices are almost sure to increase later in the year, and although the announced increase may not be so great as for the other industrial gases, the actual increase may be higher if discounting in oxygen and nitrogen continues.

Gloom hangs over European chemical industry

Belgium's Jacques Solvay, immediate past president of the European Council of Chemical Manufacturers' Federations (CEFIC), struck a somber note when he addressed that group's annual general meeting in Basel last month. He doesn't see much likelihood of a pickup in chemical business in Western Europe this year, and he can only hope for some improvement in 1983.

Citing the situation for petrochemicals and commodity plastics, two areas of the industry that are hardest pressed, he notes that overcapacities are on the order of 40%. Competition is very stringent, he adds, and imports from eastern countries, among others, are coming in at very low prices.

Chemical production index data from West Germany and the U.K. lend credence to Solvay's views. In West Germany's case, the chemical production index averaged 144.7 (1970 = 100) between January and April, 5% less than the monthly average for the corresponding period last year and in 1980.

The U.K. fared better, with a January-through-April average index of 124.7 (1970 = 100), 2% more than in 1981. "It is encouraging to see some slight improvements in several sectors of the industry, albeit from a very low level," comments Martin Trowbridge, director general of the U.K.'s Chemical Industries Association. There hardly is room for complacency, however. The four-month average so far this year is more than 9% less than the corresponding average for 1980.

The chemical price indexes for this year's first four months were up in France, West Germany, and the U.K. Compared to the four-month average in 1981, France's prices gained 15% to an index of 329.8 (1970 = 100). West German and U.K. price indexes rose about 7% to 171.5 and 403.5, respectively.

Closer scrutiny of the price index data suggests a leveling off in the growth rate. At least this was the case through April. Compared with January, April's reading was just short of 4% higher in France, a mere 0.2% ahead in West Germany, and 1% up in the U.K. In 1981, the advance over the same time period was 6% for France, almost 5% for West Germany, and 2% for the U.K. In contrast to the meager rise in West Germany's wholesale chemicals price index during the opening months of the year, coal costs there have risen 11%, electricity 16%, and natural gas 30%.

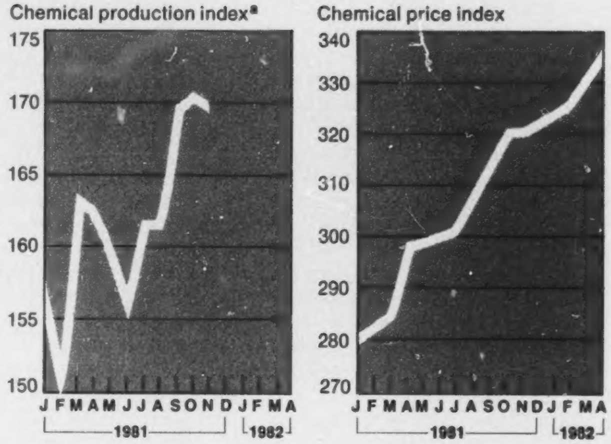
The adverse economic climate is forcing many companies out of business. Chemical concerns haven't been immune. According to data just released by Dun & Bradstreet in the U.K., there were 86 company liquidations in the chemical industry in England and Wales alone during this year's first six months—39 in the first quarter, 47 in the second.

Depressing as this situation is, the number of liquidations is 6% less than in last year's first half. And it is less than 2% of total company liquidations in England and Wales so far this year.

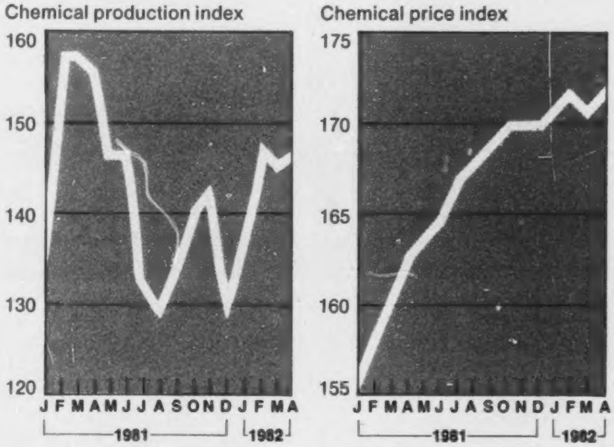
Most chemical industry executives throughout Western Europe, nevertheless, hold that companies should take steps to overcome their problems on their own, rather than seek government aid.

Dermot O'Sullivan, London

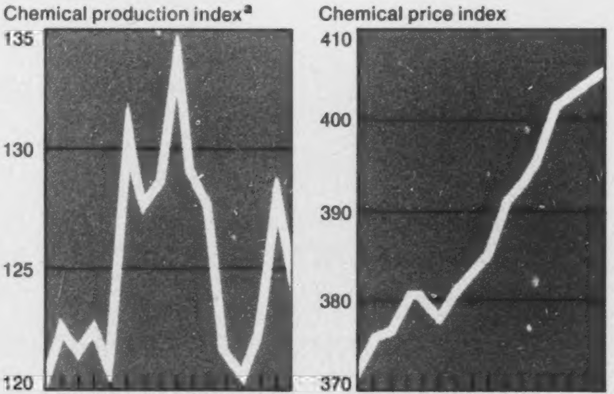
France



West Germany



U.K.



[a] Seasonally adjusted. **Note:** Base year for all indexes is 1970 = 100.

Methanol: Future fuel for electric utilities?

Electrical utilities seek independence from oil and gas suppliers by exploring ways to make their own fuel from synthesis gas

Joseph Haggin
C&EN, Chicago

Electric utility companies may wind up in the chemical business by default. The need for large quantities of clean liquid and gaseous fuels to power generating stations of the 21st century has presented the companies with a dilemma: Either continue to struggle with current financial and fuel supply difficulties or develop sources of fuels.

Development of fuel sources is being explored seriously by Electric Power Research Institute (EPRI). It now looks as though one of the most attractive alternatives is the captive production and consumption of large quantities of methanol from synthesis gas.

Driving the dilemma are a number of problems that provide strong incentives to companies for keeping existing generating plants on stream as long as possible, as well as for being quite deliberate in the acceptance of any new construction commitments—nuclear, conventional, or otherwise. These problems include severe capital shortages, escalating interest rates, and environmental constraints.

One specific problem is the amount of present generating capacity powered by oil and gas. About 200,000 MW of U.S. generating capacity is in this category, with much of the fuel being imported. Price hikes in imported fuels and in the utility rates paid by consumers have resulted in sharply reduced demand for new generating capacity in the future. They also have made the problem of satisfying off-peak power demands more acute.

Utility industry leaders continually complain about being at the mercy of oil and gas suppliers. And the prospect of a national synthetic fuels industry in the future doesn't hold many attractions for them because the synfuels producers probably will be current oil and gas producers. The net effect is a concerted effort by electric utility companies to achieve as much energy independence as possible.

Price escalations in imported fuels and progressive deregulation of domestic gas and oil have made a shambles of utility company economics. Thus, the desire for fuel with a secure supply and predictable price is too strong to resist any longer. Already firmly entrenched in the coal business, most of the larger utilities have turned to optimizing the use of coal, and one means is coproduction of gaseous fuels (medium-Btu levels) and fuel-grade methanol. This approach is particularly attractive for peaking generators, but it eventually may be the choice for baseload capacity as well.

Being an "ultraclean" liquid fuel, methanol has no trouble meeting the environmental requirements imposed by state and federal governments. It has no undesirable emissions and contributes no nitrogen oxides to stack exhausts. Methanol also burns at a lower temperature than most fuels derived from petroleum. This may or may not be an advantage, but it does make the design of methanol combustion units somewhat simpler.

Methanol and medium-Btu fuel gas are intended for use as turbine fuels either in dedicated electricity plants or in cogeneration plants, which also produce steam. So far, methanol never has been used in the U.S. as a turbine fuel, but in 1979 a 523-hour test by Southern California Edison consumed 2.5 million gal of methanol with excellent results. The biggest impediment to use of methanol at present is high price.

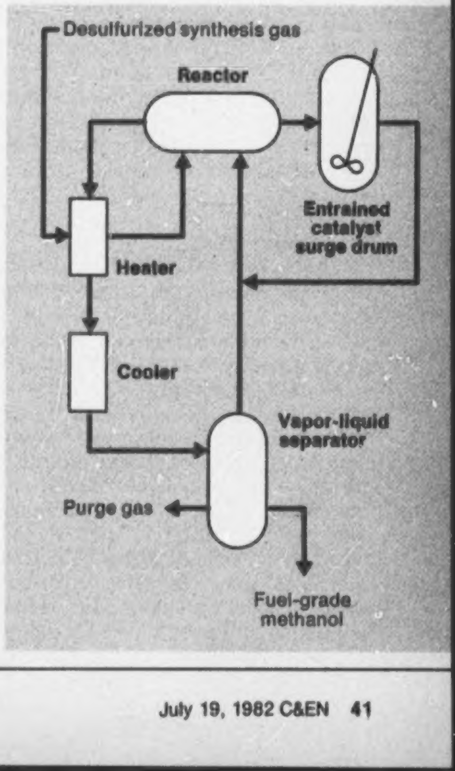
Although the conventional methanol market may be depressed, current production capacity would be insufficient to meet possible future demand for fuel-grade methanol. Most of the technology required to produce the large quantities of methanol needed for utility consumption is available. However, this technology also is intended for other purposes and would have to be adapted to the needs of utility companies.

EPRI has been examining the newer technology and appears to favor some of the second-generation gasifiers and some methanol processes that still are in the development stage. For example, the institute has been assisting development of the Texaco coal gasifier as well as Chem Systems' liquid-phase methanol process. Both of these processes now are being considered for inclusion in an integrated methanol plant to supply fuel for a cogeneration plant in southern California.

In the scenarios being developed by EPRI, two major types of plants are being considered. One is a very large baseload plant. The other is a highly flexible peaking plant, which must be capable of operating over a great range of capacity. The requirements for plants of both types are quite different from requirements for retrofitting existing plants, but both are operable with cogeneration in mind.

Intermediate-Btu fuel gas would be

Methanol process variation uses liquid-entrained catalyst reactor



Liquid-entrained catalyst reactor leads to lower methanol costs for liquid-phase process

Costs[a]	Liquid-fluidized reactor	Liquid-entrained reactor
Fixed capital, $ millions, 1980	**$60.0**	**$36.3**
Battery limits	50.0	30.3
Associated off-sites	10.0	6.0
Annual production cost, $ per ton methanol[b]	**9.5**	**2.4**
Catalyst	2.3	2.1
Utilities		
Steam	(11.2)	(11.6)
Boiler feed water	0.3	0.3
Cooling water	0.1	0.1
Power	0.4	0.6
Total	(10.8)	(10.5)
Capital-related expenses at 30%	18.0	10.8

a For 3000 tons per day of methanol in a once-through operation, with a synthesis gas feed of 817.7 million standard cu ft per day for the liquid-fluidized reactor and 511 scfd for the liquid-entrained reactor. b Excluding synthesis gas.
Source: Chem Systems

the fuel of choice for many units, but the variable demand would require some way to handle excess fuel gas during periods of low demand. One alternative is coproduction of methanol from the surplus fuel gas (synthesis gas). The methanol would be easier to store, is stable, and could be used as a clean turbine fuel as needed. That methanol is an eminently salable commodity also could offer some market leverage for potential producers.

In developing its alternative designs, EPRI has considered three major scenarios. One assumes a single-pass (no recycle) reactor that converts much of the synthesis gas from the gasifier. The most frequently cited example is the Chem Systems liquid-phase process, which converts about 25% of the feed synthesis gas to methanol in a single pass and does not require much feed pretreatment. This simplicity is desirable because it eliminates the capital costs required for recycle equipment, shift reactors to adjust composition, and other equipment.

A second possibility is to divert 30% of the synthesis gas to a methanol production unit, shifting the composition as required, removing the acid gas components, and sending the gas to a conventional process such as the ICI process or its equivalent. The remainder of the synthesis gas would be consumed directly by the generating plant. Varying amounts of the methanol then could be used to satisfy peaking demands.

A third alternative is a coal-based methanol plant in which all of the synthesis gas is converted to methanol using conventional technology.

Many variations of the three alternatives have been examined by EPRI and its consultants. The economic projections suggest that methanol coproduced by a utility company with the best available combination of processes (gasification and methanol synthesis) would cost about one third less than that purchased from a nonregulated company. Even with conventional (recycle) processes the savings could be as much as 20%.

In any case, utilities see the methanol option as a way to gain independence from other methanol producers and still offer a great deal of operating flexibility. If a utility company is contemplating construction of a new gasification/combined cycle generating plant based on coal, the net cost reduction of the liquid fuel could be as much as 40%, but much depends on local circumstances and future methanol markets.

One of the technical catches in all this is that much of the desirable technology on which the scenarios are built still is under development. Despite the availability of various gasifiers and very efficient methanol processes, the technical and economic attractiveness of the newer second-generation processes is a major incentive to speed development of these processes and to give serious consideration to bypassing the older technology.

A case in point is the combination of the Texaco coal gasification process, which evolved from a process for the partial oxidation of heavy crude oil fractions, and the Chem Systems liquid-phase methanol process, which is being developed in several variations. In July 1979, Texaco and Southern California Edison formed a group to build and operate a 1000-MW demonstration coal gasification/combined-cycle power plant at the utility's Cool Water station near Barstow, Calif. The plant is scheduled to begin operation in 1984 and will utilize the Texaco gasification process. EPRI has commissioned Fluor Corp. to evaluate the possibility of integrating a methanol facility into the Cool Water project based on the single-pass version of Chem Systems' methanol process. The goal is to determine the cost of by-product methanol from an operating plant.

One of the features of the Chem Systems process that is particularly appealing is its 68.8% conversion efficiency of coal to methanol in the single-pass version. In a conventional, dedicated methanol plant the corresponding efficiency is cited by EPRI to be usually less than 58%. The improvements in efficiency are explained by the lack of a requirement to shift the synthesis gas composition or to deacidify the synthesis gas before feeding it to the reactor. The Chem Systems process is capable of using any synthesis gas composition. The shift reactor and deacidification plant both are big consumers of energy.

The Chem Systems process is not restricted to the Texaco gasifier and at least two versions of the process are under development. One is a three-phase, bubbling-bed reactor that uses a solid proprietary catalyst in an inert hydrocarbon liquid. Synthesis gas is bubbled through the reactor medium, which provides close temperature control and permits an unusually close approach to the reaction equilibrium. Product methanol and the inert medium are immiscible and are separated easily within the reactor.

The alternative version is referred to as a liquid-entrained catalyst reactor and uses micron-sized catalyst particles suspended in the liquid to form a slurry. Catalyst slurry and synthesis gas may experience either cocurrent or countercurrent contact. The reactor liquid of choice is an aliphatic mineral oil in the C_{14} to C_{21} range. Aromatic oils and ethylene glycol also were tried with less success. The only major requirement imposed on the synthesis gas is sulfur removal before it goes into the reactor. This requirement can be met with conventional equipment. There is some variation in the product composition depending on the source (composition) of the synthesis gas, but Chem Systems says the methanol concentrations generally are greater than 90%. □

Chemical & Engineering NEWS

Tire cord makers fight for share of shrinking market
Page 13

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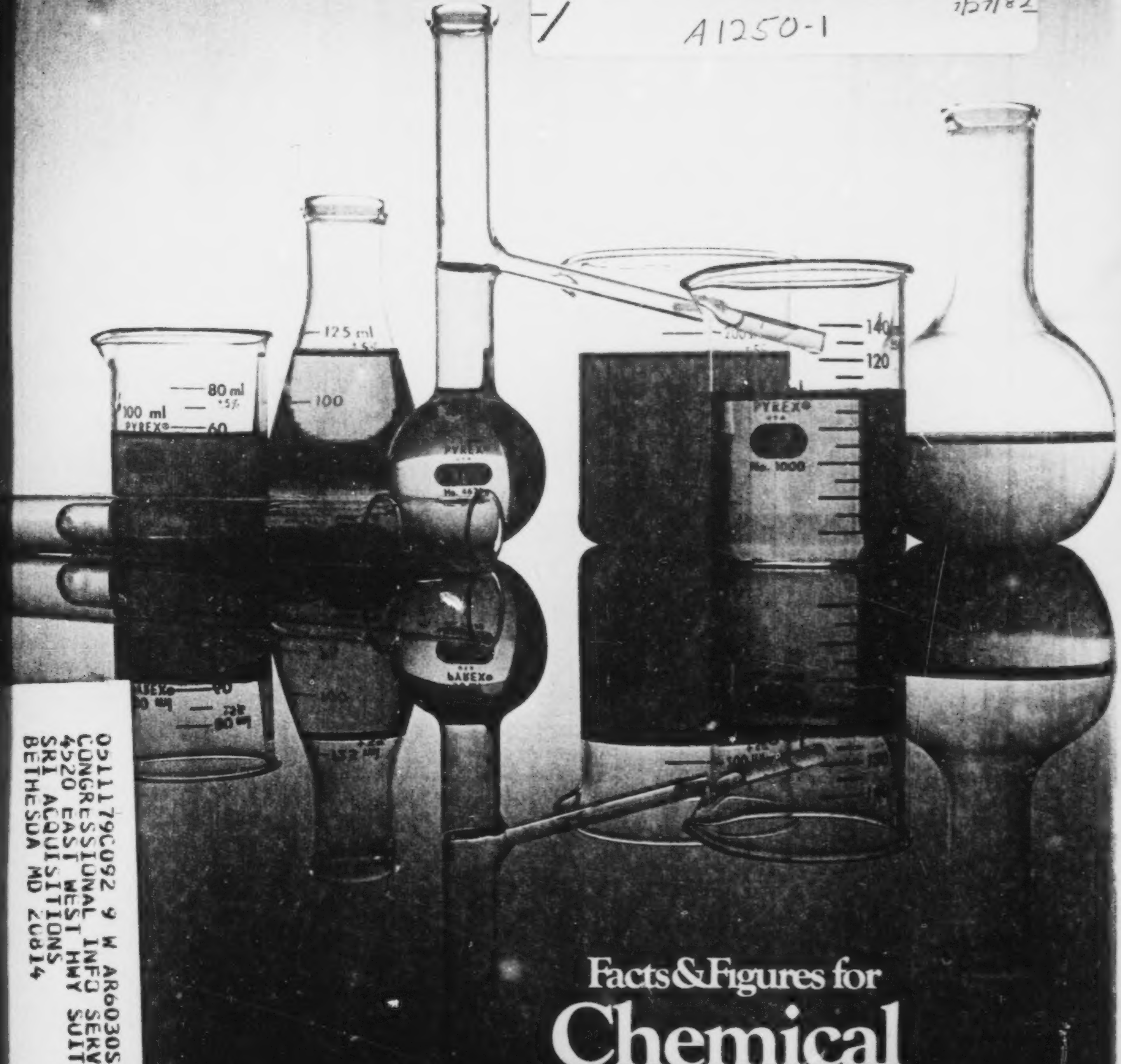
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Facts & Figures for Chemical R&D

Page 38

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Chemical & Engineering NEWS

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4 Letters
5 Editor's Page

Concentrates

10 Business
16 Government
31 Science/Technology

The Departments

58 New Products
84 Newscripts

News of the Week

- ***Second-quarter earnings reports** show a continuation of the drop in sales and earnings from last year; only bright spot is a decrease in raw materials cost.* ***Page 6***
- ***Morton Thiokol,** the new company that will result if the merger of Morton-Norwich and Thiokol goes through, will have a solid base in specialty chemicals.* ***Page 7***
- ***NRC study of future climate effects** of carbon dioxide vented into the atmosphere from burning fossil fuels reveals no new conclusions since its 1979 report.* ***Page 8***
- ***Jean Gandois resigns** as head of France's chemicals and fibers giant Rhône-Poulenc, citing dissatisfaction with the socialist government's plans for the firm.* ***Page 8***

Business

- ***Tire-cord industry faces lower demand** as sales of tires decline and amount of cord per tire drops; growing use of radials is changing tire-cord mix.* ***Page 13***

Government

- ***Unispace,** upcoming UN conference on the uses of space, will cover satellites for resource surveying and broadcasting, needs of developing countries.* ***Page 18***
- ***Appropriations for making binary nerve gas weapons** will be dropped from authorization bill if amendment introduced by bipartisan duo passes House.* ***Page 19***

Parsons Award

- ***Rep. James Martin** (R.-N.C.) receives ACS's Charles Lathrop Parsons Award for outstanding public service.* ***Page 21***

Science

- ***Fat substitute sucrose polyester** enabled obese patients to lose weight, lower serum cholesterol in Cincinnati study.* ***Page 32***
- ***Research Corp. president John Schaefer** hopes to boost academic research funding with patent royalties.* ***Page 33***

Technology

- ***Chemical propellants** power high-voltage circuit breaker in less than 36 milliseconds in Westinghouse project.* ***Page 35***

Special Report

Facts & Figures for Chemical R&D**—where money comes from, who spends it, and how—a comprehensive look at the basis of the chemical profession.* ***Page 38

ACS News

- ***ACS purchases** 82-acre Belmont Conference Center near Washington, D.C.* ***Page 75***
- ***Society urges** that patent fees be kept at levels the small businessman can afford in letter to House committee.* ***Page 76***

PROFITS PLUMMET AVERAGES 36% SO FAR

Events are bearing out earlier predictions as second-quarter results from chemical companies show another big drop from last year.

There is little good news in any of the reports thus far, as the recession seems to have spread to all segments of the chemical industry, including some previously very stable product lines such as agricultural specialties.

The only good news seems to be that in many areas the cost of raw materials has dropped far enough to allow for some profitability.

Of 20 chemical companies that have reported second-quarter earnings so far, 18 had decreases in earnings, ranging from Allied Corp.'s modest 6% drop to Akzona's going into the red. And sales declined for 17 of the companies, indicating that demand has a long way to go before the companies begin to return to reasonable profit growth.

Combined earnings for the 20 companies dropped about 36% in the quarter from the year-before period to a total of about $692 million. At the same time, combined sales for these companies declined 8% to a total of about $16.0 billion.

For the first six months of 1982, results for the 20 companies are little better. In the first half, sales fell an average of 7% from last year's first half to a combined $32.0 billion, and earnings dropped an average of 30% to a combined total of $1.46 billion.

The result is that profitability among the companies is plummeting. Average profit margin (earnings as a percentage of sales) for the 20 companies has fallen to 4.3% in the second quarter from 6.2% in the same period last year. For the first half, average profit margin was 4.6%, compared to 6.0% in first-half 1981.

It is no wonder that results are as bad as they are. Production in the chemical industry is still down considerably, giving the chemical economy quite a bit of unused production capacity. And prices are soft all through the industry as demand for product is weak back through the entire production chain.

The economic recovery that for a long time has been just around the corner, according to economists, is still that: around the corner. The problem is that every time the economy gets a step closer to that corner, the corner seems to move two steps farther away.

The automobile industry continues to slump in spite of small periods of buying, usually brought on by rebates or other sales incentives. And housing construction is still as bad as it has been, largely because of restrictive interest rates. The housing market is in such bad shape that developers not only are not selling new houses, but they have taken to auctioning off model houses in developments as a way to get rid of them and cut down carrying costs.

Fertilizers also remain in trouble as the strength of the dollar against other currencies has cut exports from

Earnings continue to drop at chemical companies

	Second-quarter 1982						First-half 1982					
	Sales	Earnings[a]	Change from 1981		Profit margin[b]		Sales	Earnings[a]	Change from 1981		Profit margin[b]	
	($ Millions)		Sales	Earnings	1982	1981	($ Millions)		Sales	Earnings	1982	1981
Air Products[c]	$ 380.7	$ 24.2	−2%	−14%	6.4%	7.2%	$ 779.7	$ 53.5	−3%	−18%	6.9%	8.1%
Akzona	254.8	−4.3	−19	def	def	1.6	545.4	−7.0	−12	def	def	1.4
Allied	1595.0	82.0	−1	−6	5.1	5.5	3209.0	145.0	−1	−15	4.5	5.4
American Cyanamid[d]	901.1	31.4	—	−35	3.5	5.0	1746.6	59.8	−2	−36	3.4	5.2
Chemed	64.8	4.0	2	−30	6.2	10.9	124.7	9.2	2	−14	7.4	8.8
Dow Chemical[e]	2728.0	77.0	−11	−59	2.8	6.2	5509.0	174.0	−8	−53	3.2	6.2
Ethyl[f]	417.6	27.9	−8	14	6.7	5.4	820.3	45.1	−7	2	5.5	5.2
H. B. Fuller	83.0	3.0	−2	−21	3.6	4.5	155.6	4.0	−4	−38	2.6	4.0
Philip A. Hunt	29.7	2.0	4	8	6.7	6.6	59.6	4.0	9	38	6.7	5.3
GAF	163.4	8.9	−6	107	5.4	2.5	302.9	5.1	−14	−31	1.7	2.1
B. F. Goodrich[g]	793.5	15.0	−4	−43	1.9	3.2	1500.0	−3.4	−6	def	def	2.2
W. R. Grace	1630.2	76.9	−4	−23	4.7	5.9	3093.4	221.1	−3	20	7.1	5.8
Hercules	651.0	22.3	−9	−46	3.4	5.8	1291.0	44.2	−6	−48	3.4	6.1
Monsanto	1623.4	86.2	−13	−8	5.3	5.1	3355.1	233.7	−11	−13	7.0	7.2
National Distillers[h]	464.9	22.3	−11	−37	4.8	6.8	929.3	39.2	−10	−44	4.2	6.7
PPG Industries	882.1	45.7	−1	−29	5.2	7.2	1600.0	69.8	−6	−42	4.4	7.0
Reichhold Chemicals	218.8	3.8	−14	−46	1.7	2.8	432.7	7.1	−12	−39	1.6	2.4
Rohm & Haas[i]	528.0	28.0	−3	−17	5.3	6.2	1003.3	44.0	−2	−28	4.4	6.0
Stauffer Chemical	305.6	17.2	−19	−25	5.6	6.1	935.9	99.3	−7	−11	10.6	11.0
Union Carbide	2299.4	118.2	−14	−35	5.1	6.8	4611.5	209.0	−13	−40	4.5	6.6

a Earnings from continuing operations, excluding extraordinary and nonrecurring items. b Earnings as a percentage of sales. c Excludes $9.3 million nonrecurring gain in second-quarter 1982. d Excludes $3.4 million charge in second-quarter 1982, $9.6 million gain in first-half 1982, and $3.4 million gain in second-quarter 1981. e Excludes nonrecurring gain of $120 million in second-quarter 1982. f Includes results from First Colony Life Insurance from May 14, 1982. g Excludes gain of $4.4 million in second-quarter 1982 and gain of $18 million in first-half 1981. h Excludes nonrecurring loss of $4.3 million in second quarter and net gain of $7.2 million in first-half 1982. i Excludes nonrecurring charge of $13.4 million in second-quarter 1981 and $9 million in first-half 1981. def = deficit.

the U.S. and purchasing power of U.S. farmers has dwindled along with farm income.

The problems on the farm in the second quarter now have spread to pesticides, which have been a rock of earnings growth over the past few years. For instance, Monsanto, which is used to seeing big increases from its Lasso and Roundup herbicides, had a 2% drop in operating profit in its agricultural products division in the second quarter.

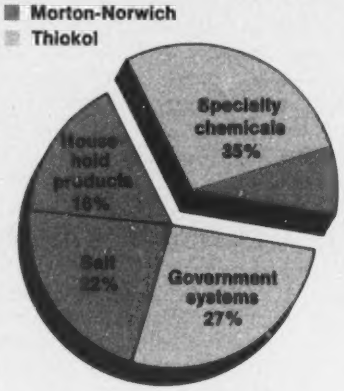
At American Cyanamid, chairman James G. Affleck says of the farm economy: "Depressed conditions in U.S. agriculture, light insect infestations, and changes in customer buying patterns all combined to reduce pesticide sales."

Lower raw material costs helped some producers in the second quarter. For instance, Union Carbide chairman Warren M. Anderson says that despite lower operating rates and depressed prices, gross profit margins in the second quarter were higher than in the same period a year ago. This was largely because of lower raw material costs and stringent cost controls, he says.

National Distillers chairman Drummond C. Bell comments that the company's high-density polyethylene operation was profitable because of lower costs for ethylene.

Just when the economy is going to turn upward is still anyone's guess, and the uncertainty seems to be troubling chemical executives. Hercules chairman Alexander F. Giacco says, "General business activity in the markets for our products showed no improvement in the second quarter. . . . As to an anticipated recovery, the industrial segment of the economy, which is capital-intensive, will show progress once the federal government resolves its financial problems. The budget situation has caused shortages of capital and, consequently, extraordinarily high interest rates. The resolution of this problem is necessary to restore confidence not only in financial markets but in consumer attitudes as well." □

Chemicals would be largest part of combined company



Total 1981 combined sales[a] = $1.47 billion

[a] Excludes sales of pharmaceutical division, sold by Morton-Norwich in June to Procter & Gamble.

Merger would be big in electronics chemicals

Morton-Norwich Products, fresh from selling a pharmaceuticals division in June to Procter & Gamble, is charting itself a new course. It is committing itself heavily to specialty chemicals by its latest decision, to acquire Thiokol. If approved by stockholders, the acquisition would result in a new company, Morton Thiokol, with more than 34% of sales in specialty chemicals.

There would be one especially significant overlap from the two merged firms' chemical markets: specialty chemicals for the electronics industry. Morton-Norwich, for example, has a major interest in epoxy molding compounds as encapsulants for semiconductors, integrated circuits, and other electronic devices. And Thiokol is building a tidy business with photoresists, solder masks, and copper deposit systems for the electronics industry.

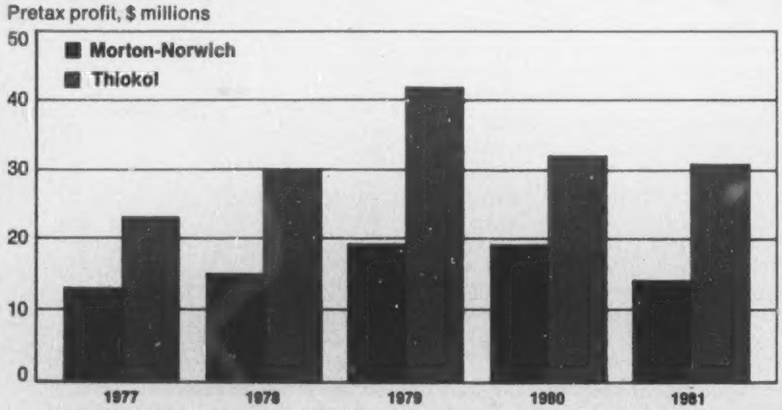
The move also would give Chicago-based Morton-Norwich a new area of sales in defense- and space-related businesses. Morton-Norwich's fiscal 1981 sales, exclusive of pharmaceuticals, totaled nearly $747 million. Of this, 44% was from salt and related products, 31% from household products, and the remainder from various specialty chemicals.

For Thiokol, presently headquartered in Newtown, Pa., 1981 sales of specialty chemicals amounted to almost $317 million, primarily for electronics applications. It also had sales of $404 million in government systems, which includes such products as solid-propellant rocket motors and propulsion systems for the military and other high-technology areas.

For the new company, a major task would be to raise profitability of chemical operations, especially in what is now Morton-Norwich. Although its specialty-chemical operations accounted for 20% of sales in the first nine months of fiscal 1982 (ended March 31), they contributed only 13% of operating profits. Similarly, household products accounted for 23% of sales, but only 17% of operating profits. Thiokol's chemicals performance was somewhat better: Specialty chemicals accounted for 44% of the company's sales in 1981 and provided 50% of operating profits.

Under the merger agreement, Morton-Norwich is offering $50 per share for up to 5.7 million shares, or approximately 49.5%, of Thiokol's common stock. Morton-Norwich also will make a tender offer for at least $70 million of its own shares. On Aug. 13, both tender offers will expire. Shareholders for the two companies will have the opportunity to vote on the merger at meetings to be called later this year, probably in September.

Both merging chemical units have profit drops



Business

Tire-cord makers vie for dwindling market

Slow automobile sales and increasing dominance of radial tires are cutting into traditional sales and shares of fibers

Patricia L. Layman
C&EN, New York

You may not be too interested in your neighbor's plans for a summer vacation. But if it happens to involve a lot of driving—across country, for example—tire-cord makers are. That's because long-distance driving will cause tires to wear out faster, so more will be needed—thereby requiring more tire cord.

Such seemingly small developments will be increasingly important to the tire-cord industry over the next few years. Not only is there a traditional flux in markets among fiber families, the entire market is shrinking as the number of tires sold declines. Also, the poundage of tire cord used in each tire is decreasing, as improved fibers impart longer life and the size of the tire itself is trimmed.

The tire-cord industry at present is probably a little shy of 700 million lb. That's up slightly—4%—from 1981 tire-cord consumption, which, in turn, was up 3% in poundage after two successive years of decline as the tire industry had dramatic slumps in production. And the outlook for growth at least appears to be encouraging: a little more than 5% per year for the next five years.

That is deceiving, however, because most of the growth is coming in steel wire, not tire cord, and that reflects the increasing market penetration by radial tires, most of which are reinforced with steel. Some 73% of passenger-car radial tires, including both replacements and original equipment, are reinforced with steel, and 92% of all truck radials have steel reinforcement. Because steel wire is heavier than synthetic fiber cord, its use on a unit-for-unit basis mounts up faster than that of fiber. Thus, as sales of radials rise, the increasing use of steel skews what otherwise would be a growth pattern showing only very slight increases, at best.

The heavier weight of steel wire, however, may give some fiber makers a means to increase their sales. By arguing that their fibers allow construction of lighter-weight tires, saving weight overall on a car or truck and thereby contributing to greater fuel economy, makers of glass fiber and aramid fiber reinforcements, in particular, are going after the radial-tire market.

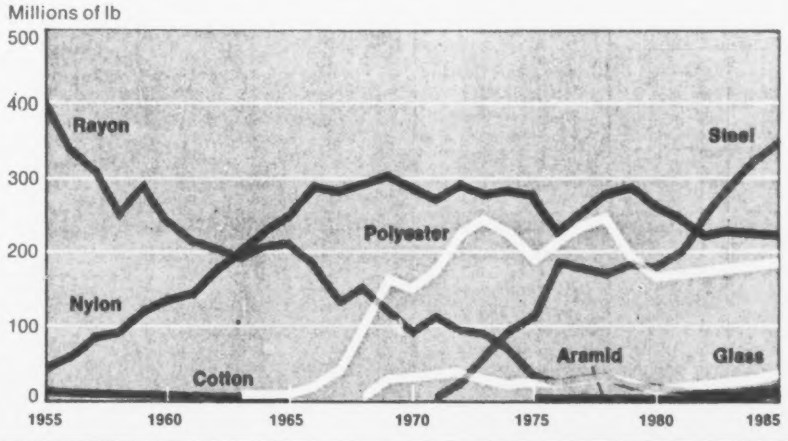
Glass fiber probably has the best chance of wresting a significant portion of the business from steel cord, because of a favorable economics picture. It is lighter than steel, and doesn't have what producers love to point out as the potential Achilles heel of steel—its poor adhesion to rubber, and a tendency to rust if a tire is nicked or slashed. And glass is lower in cost than aramid, allowing it to be considered for mass-marketed tires. But whether it reaches the optimistic position that glass-fiber makers envision remains to be seen. Fiber makers themselves acknowledge the image problem in a comparison between steel and glass. But they are relying on good performance over the years that glass fiber has been used to, to convince tire manufacturers to favor it.

Aramid makers—or more significantly, Du Pont, the only producer in the U.S. of aramid fiber—also are after the radial-tire market. But Du Pont is going after passenger-car tires and truck tires with different marketing pitches. Because the cost of aramid is steep compared with other fibers, it will be held to premium-performance passenger-car tires, the company says. High-speed performance and prestige must outweigh price.

Truck tires, on the other hand, are more promising for volume sales of aramid. Aramid fibers, Du Pont says, can replace steel on a one-to-five weight basis. That cuts weight for each tire; for large trucks, that can mean significant savings. And because the tires are lighter, they run cooler, extending the life of the tire. First target is carcass reinforcement, with Du Pont's target date the second half of 1983. The 100% aramid tire—aramid carcass and reinforcing belts—will come along more slowly, with the company figuring that 1984 would be the earliest possible date.

Although aramid fibers are competing for a market against steel carcass reinforcement in radial truck tires, glass fibers soon may be competing against polyester for carcass reinforcement in passenger-tire radials. Glass fiber makers such as Owens-Corning Fiberglas say that although the performance of their material doesn't offer any economic advantages for what is essentially the same performance as that given by polyester, within five years there will be a discernible economic advantage

Aramid fibers are latest entry in classic life-cycle of tire cord



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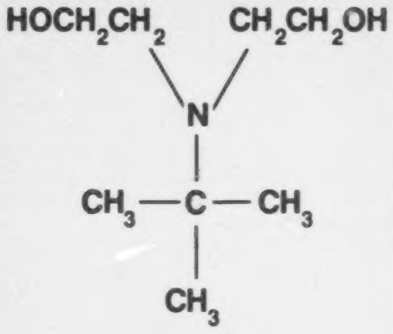

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to using glass-fiber reinforcement for radial tire carcasses.

Meanwhile, polyester producers aren't sitting still. They got into the business early on by taking a market segment—cord for bias-ply and bias-belted passenger car tires—away from nylon, and they aren't going to give up their markets without a fight. New-generation polyester fibers will help to fight off newer entrants, both Celanese and Allied think, both for the remaining, although dwindling, market for bias-ply and bias-belted passenger-car tires, and for getting into truck tires. Ironically, improved fibers may help reduce this polyester market. Monoply tires, for example, use a single-ply fiber for reinforcement belting, rather than a multiple bundle of fibers—doing as good a job with less polyester.

But new polyester variants also will expand markets, say the two companies, the only remaining polyester tire-cord suppliers. For example, according to one report, tire makers are evaluating some of the newest polyester fibers for use as a radial belt reinforcing material, a direct competitor with steel, glass fiber, and aramid.

And polyester, having a secure grip on reinforcement for passenger-car bias-ply and bias-belted tires, is going after similar work in truck tires. That market, however, is held now by nylon. Nylon producers, which watched while polyester took the passenger-car tire business away, think that truck tires are altogether a different business.

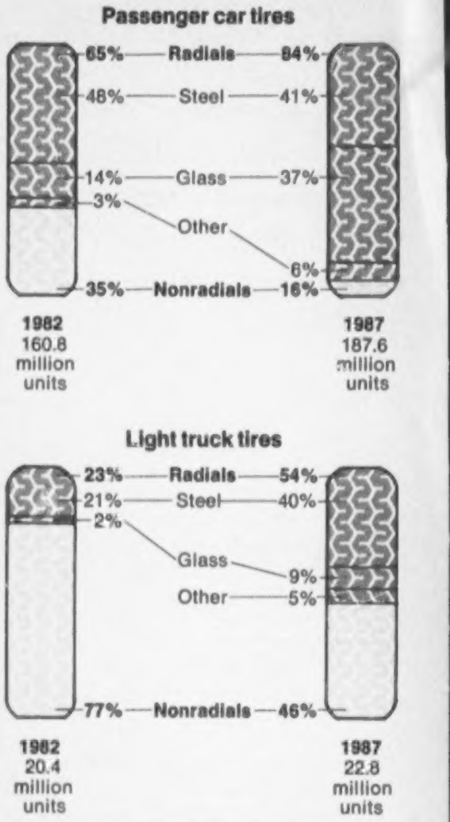
Nylon lost its hold in the passenger-car tire business, which it had wrested from rayon in the early 1960s, because of one primary drawback: the tendency to "flat-spot" in the winter. When a car was parked overnight, for example, the tire temporarily would flatten slightly along the ground, and it would take a few minutes of driving to work the thump out of the tire. Auto drivers found that annoying; Detroit got the message and turned to polyester tires for its products.

Nylon's durability and toughness, however, proved ideal for truck tires, which still are primarily bias ply or bias belted. And nylon cord producers—the only three in the U.S. now are Allied, Du Pont, and Monsanto—believe that bias-ply and bias-belted truck tires will continue to dominate for quite a while.

Radial tires, they point out, are exceptionally well suited for long-distance driving over good roads. But many trucks are designed for off-the-road operation, or are driven short distances, or are driven on poor roads. And in international markets, good highways—interstate or autobahn quality, for example—are the exception, not the rule. Under those conditions, there would be less incentive from a tire-performance viewpoint to switch from bias-ply to radial tires. If a developing country already had technology for making bias-ply tires, there probably would be even less incentive. Nylon will continue to be the fiber of choice there, producers predict, adding that, indeed, it will be a growth fiber.

Meanwhile, rayon continues to survive as a tire cord, even as critics try to write obituaries for it. It's still used widely for bias-ply tires in Europe—in particular as an alternative to radials—and also in radials with steel wire. In the U.S., it was nearly done in as a tire fiber because of environmental costs associated with its production. But rayon makers say those costs have been absorbed, and that the fiber is competitive with polyester, especially for premium-priced replacement tires. That's

Growing dominance of radials will revamp tire cord demand



especially true, they say, since polyester prices have firmed with the shutdown of excess capacity and the pulling out from the market by Du Pont last year and by American Cyanamid in 1980.

Rayon tire cord "isn't a growth business, but it can be a good business," says one marketer. "We see the cost-performance ratio for polyester and rayon going head-on, and there's a good long-term future."

For manufacturers of all the tire cord fibers, however, the outlook for the entire industry is not one of dramatic growth. Too many factors will hold the business down. Car sales this year, for example, are having a dramatic impact on sales of original-equipment tires, which make up about 25% of passenger-car tires. General Motors, for example, reported that first-half 1982 sales were down 10% from first-half 1981. Its commercial-vehicle sales (light-duty trucks and vans) were up 22%, but that category is only about one third the size of its passenger-car group.

Those cars that are being sold are increasingly the down-sized compacts and subcompacts, which use a down-sized tire; the most popular-sized tire last year, for replacement tires, was 14 inches. With the pressure on Detroit to make cars with increasingly high gasoline mileage ratings, the pressure to save weight falls back on the tire makers, too, forcing them to look at ways to use monoply construction, for example, or substitute lighter-weight materials.

Because the American public has been through several years of high gasoline prices and often spotty availability, they haven't been driving all that much—meaning they haven't been wearing out their tires.

Fiber makers will have to become more attuned to metallurgical developments, as steel cord increases its market penetration. One tire maker says that steel-cord producers are at the same stage of adapting product to the market that polyester fiber producers were in the 1960s. So there may be an opportunity to develop synthetic fibers to work specifically with steel wire tailored for tire cord.

Nevertheless, the market still is profitable for those who are staying in. As marginal producers drop out, or phase out fiber lines, that will leave enough market for those remaining. And with some judicious diversification into other types of industrial fibers—for applications such as hose, rope, liner fabrics—producers will be able to ride out the current hard times in auto and tire sales. ☐

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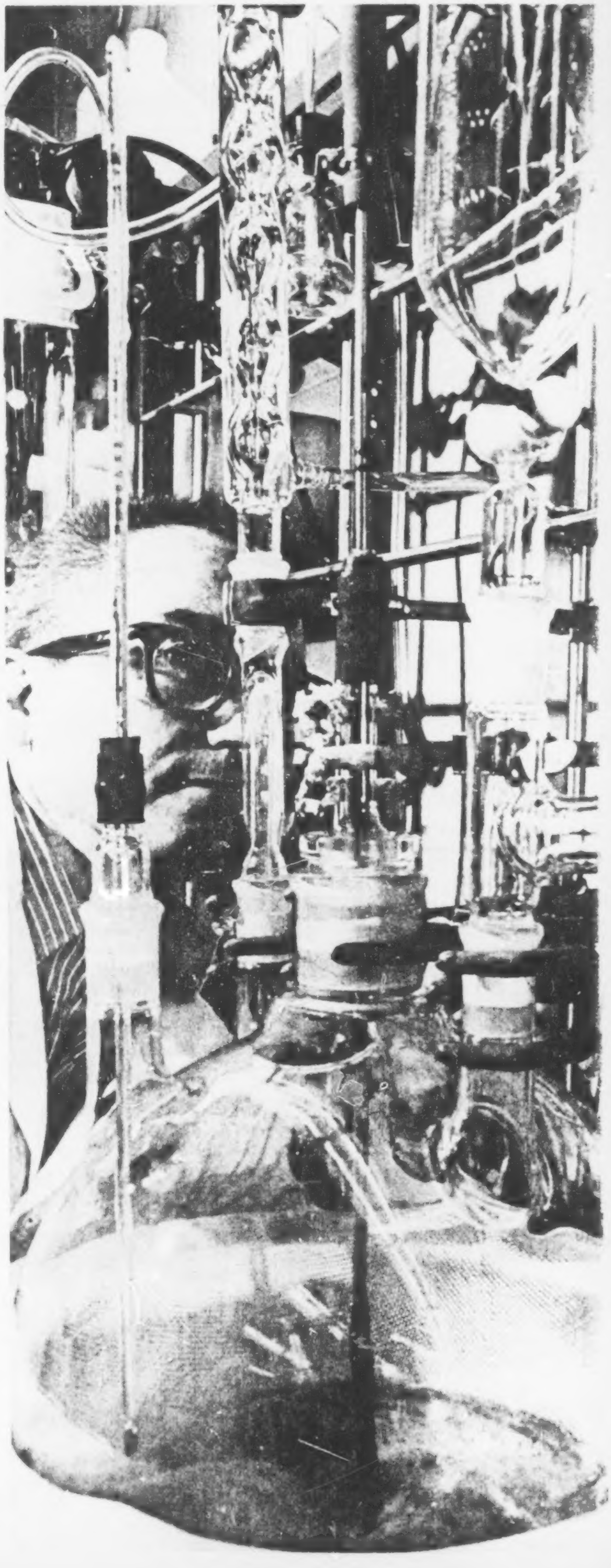
Facts&Figures for Chemical R&D



1 SECTION ONE

Overview 40

A look at the nation's total R&D effort. Where funds come from. Who spends them. How they are divided among basic and applied research and development. Manpower and publication trends

2 SECTION TWO

Federal government 47

R&D funding by the U.S. government. How much federal agencies spend and what they spend it on

3 SECTION THREE

Industry 63

Outlays for R&D by the chemical industry and other industrial sectors. Budgets of individual chemical firms. Manpower in industrial R&D

4 SECTION FOUR

Universities and colleges 68

Where academic institutions get R&D money and how they use it. What schools spend most. Degrees in chemistry/chemical engineering

ABSTRACTS OF PAPERS IN *CHEMICAL ABSTRACTS*: **Changes are relatively small**

% IN EACH GROUP	1981	1980	1979	1978	1977	1976	1975	1974	1973
Biochemistry	39.0%	39.8%	38.8%	38.3%	37.9%	38.8%	39.4%	36.2%	35.9%
Physical and analytical chemistry[a]	28.0	28.6	28.9	27.4	27.9	27.5	29.6	29.7	31.0
Applied chemistry and chemical engineering	19.1	18.9	19.4	20.8	19.7	18.8	15.5	18.4	16.7
Organic chemistry	8.7	7.4	7.6	8.0	8.8	8.7	9.0	9.4	10.0
Macromolecular chemistry	5.2	5.3	5.3	5.5	5.7	6.2	6.5	6.3	6.4
% OF ALL BIOCHEMISTRY ABSTRACTS									
Mammalian biochemistry	15.6%	16.3%	17.1%	17.2%	17.7%	16.3%	15.3%	16.6%	13.7%
Pharmacodynamics	12.4	12.0	11.9	12.3	12.0	12.0	12.0	11.1	11.1
Toxicology	8.7	8.3	7.4	7.5	6.2	6.4	6.6	5.6	5.9
General biochemistry	7.5	6.6	7.0	6.5	7.0	7.1	7.5	7.3	7.9
Enzymes	5.9	6.2	6.4	5.7	6.1	6.4	7.4	6.4	5.8
Others	49.9	50.6	50.2	50.8	51.0	51.8	51.2	53.0	55.6
% OF ALL PHYSICAL AND ANALYTICAL CHEMISTRY ABSTRACTS[a]									
Nuclear chemistry	21.6%	23.2%	25.1%	20.7%	21.1%	19.7%	20.0%	15.8%	19.0%
Spectra	18.0	18.2	17.0	17.0	18.1	17.8	17.2	18.2	16.8
Electric phenomena	11.0	11.2	11.4	10.9	10.5	10.5	10.3	11.4	10.8
Crystallization and crystal structure	8.9	8.1	8.2	9.2	8.9	9.7	9.6	10.1	10.2
General physical chemistry	7.2	7.1	6.6	6.6	6.8	7.0	6.8	6.4	7.2
Analytical chemistry	5.8	5.6	5.6	7.2	5.8	6.6	6.1	7.4	6.9
Others	27.5	26.6	25.8	28.4	28.8	28.7	30.0	30.7	29.1
% OF ALL APPLIED CHEMISTRY AND CHEMICAL ENGINEERING ABSTRACTS									
Metals and alloys	17.9%	22.0%	23.6%	24.0%	24.2%	27.8%	24.4%	27.9%	24.2%
Water, wastes, and pollution	24.0	22.5	20.8	20.8	23.2	18.6	15.2	18.2	15.6
Mineralogical and geological chemistry	14.1	15.7	15.8	16.8	13.4	17.6	17.5	17.6	20.2
Fossil fuels, derivatives, and related products	9.4	8.9	7.8	8.2	9.2	6.0	9.8	4.0	8.0
Unit operations and processes	6.4	6.0	6.1	6.4	5.8	4.8	5.3	5.6	7.8
Others	28.2	24.9	25.9	23.8	24.2	25.2	27.8	26.7	24.2
% OF ALL ORGANIC CHEMISTRY ABSTRACTS									
Physical organic chemistry	37.0%	38.8%	38.8%	36.8%	41.3%	38.4%	40.8%	37.3%	37.2%
Heterocyclic compounds	18.2	17.3	16.0	17.5	17.0	17.4	16.4	17.3	17.8
Organometallic and organometalloidal compounds	8.3	8.2	8.5	8.9	8.5	8.7	8.4	8.2	7.8
Aromatic compounds	8.7	7.8	8.2	8.6	8.5	8.0	8.7	9.4	10.0
Aliphatic compounds	6.6	6.0	6.0	6.9	5.9	6.5	6.3	7.1	7.1
Carbohydrates	5.4	5.7	6.0	5.2	4.6	5.1	4.9	5.5	5.6
Others	15.8	16.2	16.5	16.1	14.2	15.9	14.5	15.2	14.5
% OF ALL MACROMOLECULAR CHEMISTRY ABSTRACTS									
Plastics manufacture and uses	26.4%	28.1%	27.8%	28.1%	27.5%	26.8%	23.3%	23.1%	24.9%
Synthetic high polymers	30.3	27.0	26.3	25.6	26.5	28.3	30.6	30.6	27.7
Cellulose, lignin, paper, and other wood products	10.1	10.9	11.1	10.6	10.0	9.1	9.2	9.2	9.8
Textiles	9.9	10.1	10.1	12.1	11.0	11.1	10.2	9.8	11.0
Coatings, inks, and related products	7.5	7.4	8.1	7.5	7.5	7.6	7.3	8.1	8.1
Elastomers, including natural rubber	7.9	8.4	7.6	8.0	8.5	8.6	9.2	10.4	9.2
Others	7.9	8.1	9.0	8.1	9.0	8.5	10.2	8.8	9.3

[a] Includes inorganic chemistry. **Source:** Chemical Abstracts Service

U.S. PATENTS: **No significant change in total last year**

	1981	1980	1979[a]	1978	1977	1976	1975	1974	1973	1972	1971
U.S.[b]	37,356	37,152	30,605	40,979	41,383	44,162	46,603	50,643	51,501	51,515	55,988
Foreign[c]	24,463	24,675	18,248	25,123	23,886	26,074	25,291	25,632	22,638	23,293	22,328
TOTAL	**61,819**	**61,827**	**48,853**	**66,102**	**65,269**	**70,236**	**71,994**	**76,275**	**74,139**	**74,808**	**78,316**
% Foreign	**39.6%**	**39.9%**	**37.4%**	**38.0%**	**36.6%**	**37.1%**	**35.3%**	**33.6%**	**30.5%**	**31.1%**	**28.5%**

[a] Patent figures were low in 1979 because the Patent & Trademark Office was short of funds to print patents it might otherwise have issued. [b] U.S. patents granted to U.S. residents. [c] U.S. patents granted to residents of foreign countries. **Source:** Patent & Trademark Office

2 R&D *SECTION TWO* **Federal government**

Defense spurs rise in federal R&D funding

Government obligations for R&D will climb 15% in fiscal 1982, thanks largely to a 28% increase in Defense Department funding

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FEDERAL OBLIGATIONS FOR R&D: Defense and space get largest increases

Department or agency	Total R&D ($ millions) 1982[a]	1981[a]	1980	1979	1978
Agriculture	$ 860.0	$ 770.3	$ 687.6	$ 663.0	$ 621.3
Science & Education Administration	675.1	600.9	536.0	518.4	483.0
Commerce	288.0	336.8	342.5	309.4	283.7
National Bureau of Standards	93.5	83.0	76.2	67.8	58.3
Defense	21,523.2	16,864.1	13,981.0	12,506.2	11,553.6
Air Force	9,524.4	7,196.0	5,211.0	4,525.6	4,262.3
Army	4,020.3	3,291.0	2,980.0	2,768.7	2,548.9
Navy	6,057.6	5,061.8	4706.1	4,335.0	3,998.4
Energy	4,690.2	4,926.7	4,753.7	4,638.8	4,244.8
Environmental Protection Agency	302.6	363.1	345.0	410.1	384.6
Health & Human Services	4,168.6	3,904.8	3,780.2	3,504.9	3,207.3[b]
National Institutes of Health	3,570.8	3,328.3	3,181.8	2,953.1	2,580.9
Interior	397.8	422.9	411.3	405.8	385.2
National Aeronautics & Space Administration	6,017.4	5,407.7	5,084.1	4,411.0	3,875.4
National Science Foundation	999.9	937.4	881.8	807.9	748.8
Tennessee Valley Authority	95.5	91.1	80.1	38.4	31.5
Others	1,258.9	1,355.8	1,333.0	1,282.9	1,078.1
TOTAL	$40,602.1	$35,380.7	$31,680.3	$28,978.4	$26,414.3

a Estimated. b For Department of Health, Education & Welfare. **Note:** Fiscal years. **Source:** National Science Foundation

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FEDERAL OBLIGATIONS FOR RESEARCH: Fell in 1981, expected to rise in 1982

Department or agency, $ millions	1982[a] Basic research	1982[a] Applied research	1981[a] Basic research	1981[a] Applied research	1980 Basic research	1980 Applied research	1979 Basic research	1979 Applied research	1978 Basic research	1978 Applied research
Agriculture	$ 362.9	$ 462.8	$ 319.3	$ 419.4	$ 275.6	$ 381.8	$ 256.4	$ 375.5	$ 242.7	$ 351.8
Science & Education Administration	310.8	338.5	271.2	305.7	233.0	279.8	218.6	274.8	207.9	253.2
Commerce	36.7	192.0	32.2	225.2	29.9	224.5	24.6	194.7	23.9	168.9
National Bureau of Standards	18.9	56.6	16.0	49.2	12.8	46.1	8.8	43.0	5.9	42.6
Defense	722.0	2426.2	612.9	1971.1	540.3	1721.4	363.3	1788.3	319.1	1622.1
Air Force	153.7	513.6	127.7	480.5	108.2	429.1	96.8	653.9	95.1	590.6
Army	192.4	447.1	143.1	370.7	132.2	347.1	59.5	402.7	54.5	359.8
Navy	282.0	526.4	240.4	461.1	214.9	396.2	147.7	285.1	130.3	271.7
Energy	681.7	939.1	594.7	812.7	523.1	754.2	463.0	668.9	440.5	661.7
Environmental Protection Agency	13.8	201.4	14.2	245.7	13.6	231.5	10.1	248.9	6.0	246.7
Health & Human Services	2017.0	1681.7	1871.6	1598.8	1762.7	1570.1	1576.0	1439.7	1292.3[b]	144[illegible][b]
National Institutes of Health	1833.6	1270.4	1745.6	1188.6	1642.3	1145.1	1463.7	1066.4	1181.1	1051.5
Interior	79.2	273.6	77.3	287.0	71.6	282.8	72.5	266.9	145.7	164.1
National Aeronautics & Space Administration	593.0	1060.9	540.4	1014.2	559.1	1050.5	512.8	938.4	479.7	865.4
National Science Foundation	945.4	54.4	873.6	59.8	815.2	58.4	733.3	66.8	678.0	35.5
Tennessee Valley Authority	5.0	15.7	4.9	12.9	4.6	11.2	4.1	12.4	3.8	9.7
Others	99.2	690.1	95.3	674.5	92.2	622.6	81.0	575.4	67.4	447.5
TOTAL	$5555.9	$7997.8	$5036.4	$7321.3	$4692.4	$8054.1	$4097.3	$6575.9	$3699.1	$6051.8

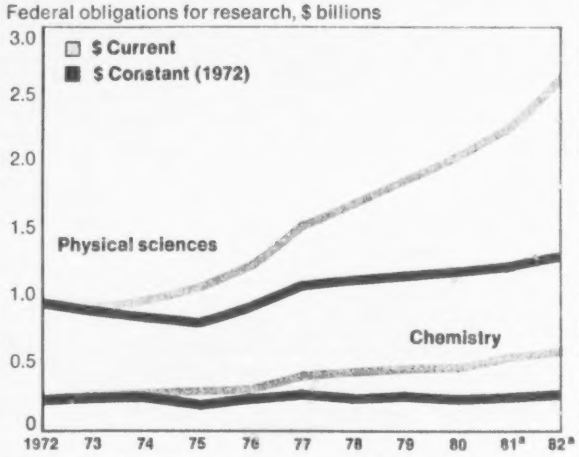
a Estimated. b For Department of Health, Education & Welfare. **Note:** Fiscal years. **Source:** National Science Foundation

FEDERAL OBLIGATIONS FOR SCIENTIFIC DISCIPLINES: Physical sciences get 20% of total

$ Millions for research only	1982[a]	1981[a]	1980	1979	1978	Annual change 1981–82	Annual change 1978–82
Engineering	$ 3,376	$ 3,027	$ 2,830	$ 2,623	$2446	11%	8%
Chemical	145	160	96	124	153	−9	−2
Metallurgy and materials	340	264	236	251	295	29	4
Environmental sciences	1,377	1,276	1,261	1,103	1050	8	7
Life sciences	4,714	4,435	4,192	3,850	3430	6	8
Mathematics and computer sciences	322	284	241	257	236	13	8
Physical sciences	2,644	2,234	2,001	1,822	1683	18	2
Chemistry	570	513	454	453	416	11	8
Physics	1,658	1,373	1,182	1,044	965	21	14
Other sciences	1,100	1,102	1,073	1,018	906	0	5
TOTAL	$13,533	$12,358	$11,598	$10,673	$9751	9%	8%

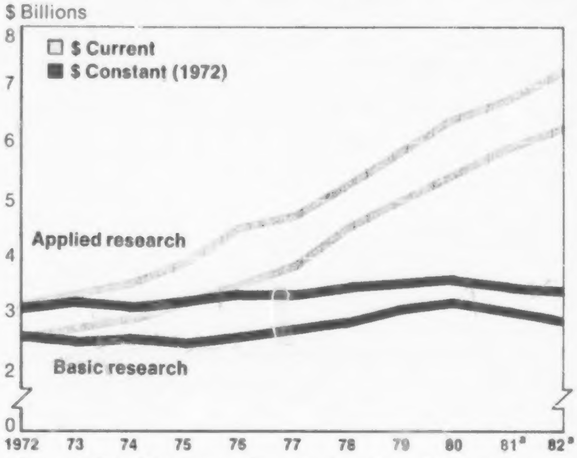
a Estimated. **Note:** Fiscal years. **Source:** National Science Foundation

Chemistry's share of federal funding for physical science has declined slightly



a Estimated. **Note:** Fiscal years. **Source:** National Science Foundation

Federal support of research tending downwards in constant dollars



a Estimated. **Note:** Calendar years. **Source:** National Science Foundation

FEDERAL OBLIGATIONS FOR DEVELOPMENT: Defense, space account for growth this year

Department or agency	Development ($ millions) 1982[a]	1981[a]	1980	1979	1978
Agriculture	$ 34.3	$ 31.6	$ 30.1	$ 31.1	$ 26.8
Science & Education Administration	25.8	24.0	23.3	24.9	21.8
Commerce	59.3	79.4	88.1	89.9	90.9
National Bureau of Standards	18.0	17.8	17.3	16.0	9.8
Defense	18,375.0	14,280.1	11,719.2	10,354.6	9,612.4
Air Force	8,875.1	6,587.7	4,673.7	3,774.9	3,576.6
Army	3,380.7	2,777.1	2,500.7	2,306.5	2,134.6
Navy	5,249.2	4,360.3	4,095.0	3,902.2	3,596.4
Energy	3,069.4	3,519.3	3,476.4	3,506.9	3,142.6
Health & Human Services	469.9	434.3	447.4	489.2	466.5
National Institutes of Health	416.8	394.0	394.4	423.0	348.3
Interior	44.9	58.6	56.8	66.3	75.5
Environmental Protection Agency	87.4	103.2	99.9	151.1	132.0
National Aeronautics & Space Administration	4,363.4	3,853.1	3,474.4	2,959.8	2,530.2
National Science Foundation		4.0	8.1	7.9	5.3
Tennessee Valley Authority	74.8	73.3	64.3	21.9	18.0
Others	489.6	564.1	638.2	626.5	563.2
TOTAL	$27,068.1	$22,436.9	$20,103.2	$18,305.2	$16,663.4

a Estimated. **Note:** Fiscal years. **Source:** National Science Foundation

BASIC RESEARCH: Defense Department support of basic chemistry rising rapidly

	Federal obligations ($ millions)									
	1982[a]		1981[a]		1980		1979		1978	
Department or agency	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry
Agriculture	$ 33.7	$ 31.5	$ 30.4	$ 28.4	$ 25.8	$ 24.0	$ 23.8	$ 22.3	$ 25.4	$ 23.6
Science & Education Administration	31.4	29.7	28.3	26.8	23.8	22.5	22.3	21.0	23.2	21.9
Commerce	15.9	2.9	13.9	2.5	12.4	2.3	8.9	1.7	6.6	1.0
National Bureau of Standards	14.5	2.7	12.8	2.5	11.0	2.2	7.9	1.6	5.7	0.9
Defense	208.0	50.9	193.0	42.8	167.1	35.7	69.9	24.5	73.1	20.9
Air Force	32.8	13.3	29.5	11.8	24.8	10.4	24.0	10.0	22.5	9.0
Army	64.5	19.0	48.6	14.8	46.0	12.7	9.7	4.3	9.3	3.7
Navy	90.0	18.4	81.0	16.0	71.9	12.3	43.6	10.1	37.9	8.2
Energy	560.9	79.8	490.4	70.9	432.1	62.1	345.6	57.7	325.4	47.9
Environmental Protection Agency	5.7	5.7	4.5	4.5	2.2	2.2	1.8	1.8	1.7	1.3
Health & Human Services	61.4	54.3	56.9	50.3	53.7	47.4	40.7	36.7	32.9[b]	29.8[b]
National Institutes of Health	60.6	53.5	56.2	49.6	52.9	46.6	40.3	36.3	32.7	29.6
Interior	8.6	6.3	8.3	5.9	7.5	5.3	9.1	6.5	12.9	10.2
Geological Survey	3.1	2.1	3.3	2.2	2.6	1.7	2.6	1.7	8.9	7.7
National Aeronautics & Space Administration	321.0	4.8	283.3	6.5	309.0	5.2	292.5	5.3	243.1	8.9
National Science Foundation	254.2	87.4	219.5	74.0	198.6	68.4	197.1	60.3	189.8	56.7
Tennessee Valley Authority	3.3	3.3	3.2	3.2	3.1	3.1	2.7	2.7	2.4	2.4
Others	6.5	0	10.7	1.2	10.0	1.2	9.4	1.3	9.1	1.5
TOTAL	$1481.2	$326.9	$1314.1	$290.2	$1221.5	$256.9	$1021.5	$220.8	$922.4	$204.2

a Estimated. b For Department of Health, Education & Welfare. **Note:** Fiscal years. **Source:** National Science Foundation

APPLIED RESEARCH: Chemistry's share of total for physical sciences is declining

	Federal obligations ($ millions)									
	1982[a]		1981[a]		1980		1979		1978	
Department or agency	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry
Agriculture	$ 32.6	$ 30.2	$ 29.5	$ 27.3	$ 26.9	$ 24.9	$ 26.9	$ 25.0	$ 26.7	$ 24.3
Science & Education Administration	29.7	28.2	26.8	25.5	24.4	23.2	24.5	23.2	23.8	22.5
Commerce	29.7	8.2	28.3	7.3	26.3	7.2	26.6	7.2	25.9	7.2
National Bureau of Standards	24.7	7.0	23.7	6.3	21.3	6.0	21.9	6.1	21.8	6.2
Defense	463.8	56.8	313.6	46.5	243.4	42.5	295.5	73.1	285.3	50.4
Air Force	51.7	13.4	47.1	13.1	41.5	12.5	96.0	19.6	71.9	13.8
Army	69.2	29.3	54.5	29.0	54.3	24.2	80.6	46.8	74.9	26.3
Navy	133.6	13.6	101.6	9.0	59.0	5.3	62.6	6.2	62.7	9.6
Energy	507.6	47.5	412.1	29.1	360.0	22.2	317.7	14.6	290.5	28.2
Environmental Protection Agency	64.5	64.5	78.5	78.5	69.4	68.4	71.4	70.7	69.1	66.4
Health & Human Services	28.9	24.9	26.8	23.1	26.0	22.5	29.1	26.1	25.4[b]	22.6[b]
National Institutes of Health	28.1	24.1	26.3	22.6	25.4	21.8	28.8	25.9	24.3	21.6
Interior	7.2	5.4	6.7	4.8	6.4	4.4	6.6	5.3	6.0	5.0
Geological Survey	5.0	4.0	4.8	3.8	3.7	2.9	4.0	3.2	4.3	3.4
National Aeronautics & Space Administration	16.5	1.2	12.5	1.1	12.2	1.5	12.3	1.1	21.7	0.3
National Science Foundation	6.8	3.1	6.3	2.9	4.6	2.3	8.7	5.3	5.9	3.6
Others	5.0	1.4	5.1	1.9	3.7	1.5	2.5	1.2	1.5	0.4
TOTAL	$1162.6	$243.2	$919.4	$222.5	$778.9	$197.4	$797.3	$229.6	$758.0	$208.4

a Estimated. b For Department of Health, Education & Welfare. **Note:** Fiscal years. **Source:** National Science Foundation

Most programs get an increase

$ Millions	1983 Probable Congressional authorization[a]	1983 Administration request	1982[b]	1981	1980	% change 1982-83[c]
Nuclear fission	$1088.0	$ 830.2	$1087.4	$ 950.5	$ 951.8	0%
Fossil energy	479.0	106.9	416.9	993.8	732.1	15
General science and research	567.5	600.9	542.7	509.4	339.9	4
Magnetic fusion	473.5	444.1	453.8	394.1	248.0	4
Basic energy research	333.7	293.8	260.2	281.3	214.4	28
Solar energy	303.0	72.2	256.9	551.4	451.9	18
Environmental R&D	230.8	139.0	219.3	226.8	201.5	5
Conservation	182.0	17.5	81.2	290.2	397.3	124
Electric energy systems and storage	67.0	37.0	49.5	111.7	94.0	35
Geothermal	55.4	0	58.5	156.0	116.2	−5
TOTAL	**$3779.7**	**$2541.6**	**$3367.9**	**$4465.2**	**$3441.1**	12%

a C&EN estimate based on House and Senate action to date. b Estimate. c Based on probable Congressional authorization. **Note:** Fiscal years.

Funded essentially at level of Administration request

$ Millions	1983 Probable Congressional authorization[a]	1983 Administration request	1982[b]	1981	1980	% change 1982-83[c]
Mathematical and physical sciences	$ 298.7	$ 298.7	$272.9	$ 256.5	$227.0	9%
Astronomical, atmospheric, earth, and ocean sciences	259.7	259.7	240.0	236.3	218.0	8
Biological, behavioral, and social sciences	191.7	186.7	176.0	185.6	185.7	9
Engineering	99.7	99.7	92.0	86.3	76.6	8
Antarctic program	86.4	86.4	66.0	67.4	55.8	31
Program development and management	63.1	63.1	63.5	59.2	58.2	−1
Scientific, technological, and international affairs	50.1	44.0	40.3	53.7	36.6	24
Science and engineering education	25.0	15.0	20.9	70.6	77.2	20
Ocean drilling programs	14.0	14.0	20.0	22.0	19.4	−30
Special foreign currency	2.2	2.2	4.6	4.0	4.7	−52
TOTAL	**$1090.6**	**$1069.5**	**$996.2**	**$1041.6**	**$959.2**	9%

a C&EN estimate based on Congressional action to date. b Estimate. c Based on probable Congressional authorization. **Note:** Fiscal years.

A little less than requested, but still up 15%

$ Millions	1983 Probable Congressional authorization[a]	1983 Administration request	1982[b]	1981	1980	% change 1982-83[c]
Air Force	$10,577.3	$11,220.4	$ 8,819.3	$ 7,133.3	$ 5,055.8	20%
Army	4,053.5	4,484.0	3,609.5	3,127.8	2,846.4	12
Navy	6,164.5	6,235.3	5,810.2	4,997.0	4,572.1	6
Defense agencies	2,202.4	2,320.7	1,697.6	1,308.9	1,044.1	30
Director, test, and evaluation	58.5	60.0	53.0	42.1	42.5	10
TOTAL	**$23,056.2**	**$24,320.3**	**$19,989.6**	**$16,609.1**	**$13,560.9**	15%

a C&EN estimate based on Congressional action to date. b Estimate. c Based on probable Congressional authorization. **Note:** Fiscal years.

Emphasis in 1983 is on shuttle operations

	1983					
$ Millions	**Probable Congressional authorization**[a]	**Administration request**	**1982**[b]	**1981**	**1980**	**% change 1982–83**[c]
Conduct of R&D	**$5350.8**	**$5125.0**	**$4772.2**	**$4332.4**	**$4048.9**	12%
Space shuttle	1757.2	1718.0	2163.0	1995.0	1871.0	−19
Space flight operations	1573.5	1707.0	895.9	679.2	446.6	76
Tracking & data acquisition	503.9	508.9	402.1	339.9	332.1	25
Physics & astronomy	477.6	471.7	323.5	323.7	336.8	48
Space applications	333.3	316.3	328.2	331.5	331.6	2
Aeronautical research & technology	281.5	232.0	264.8	271.4	308.3	6
Planetary exploration	185.8	154.6	205.0	175.6	219.9	−9
Space research technology	130.5	123.0	111.0	110.7	115.6	17
Life sciences	55.7	55.7	39.5	42.2	43.8	41
Expendable launch vehicles	42.8	42.8	31.2	54.4	31.2	37
Technology utilization	9.0	4.0	8.0	8.8	12.0	12
Research & program management	**1174.0**	**1178.9**	**1144.7**	**1071.1**	**996.0**	2
Construction of facilities	**105.0**	**100.0**	**98.7**	**116.9**	**159.1**	6
TOTAL	**$6629.8**	**$6403.9**	**$6015.6**	**$5520.4**	**$5204.0**	10%

a C&EN estimate based on House and Senate action to date. b Estimate. c Based on probable Congressional authorization. **Note:** Fiscal years.

Continues its downward trend

	1983					
$ Millions	**Probable Congressional authorization**[a]	**Administration request**	**1982**[b]	**1981**	**1980**	**% change 1982–83**[c]
Air quality	$ 55.7	$ 47.2	$ 55.7	$ 59.0	$ 68.0	0%
Energy	51.5	34.5	52.5	84.1	103.0	−2
Water quality	39.7	27.7	45.1	49.9	67.0	−12
Hazardous waste	33.9	29.6	29.5	28.3	13.0	15
Toxic substances	28.1	26.6	31.2	30.0	31.0	−10
Drinking water	25.9	22.9	28.3	21.8	23.0	−8
Interdisciplinary	10.8	4.2	5.7	6.1	8.0	89
Pesticides	6.5	6.5	5.6	7.9	13.0	16
Radiation	2.0	1.6	2.5	2.4	3.0	−20
TOTAL	**$254.1**	**$196.0**	**$256.1**	**$289.5**	**$329.0**	−1%

a C&EN estimate based on House and Senate action to date. b Estimate. c Based on probable Congressional authorization. **Note:** Fiscal years.

Administration is asking for a modest 2% increase

$ Millions	**1983**[a]	**1982**[b]	**1981**	**1980**	1979	**% change 1982–83**[c]
National Institutes	**$3449.5**	**$3370.0**	**$3305.6**	**$3182.5**	**$2934.8**	2%
Cancer	955.4	986.6	989.3	999.8	937.1	−3
Heart, lung & blood	577.1	559.6	549.7	527.5	510.1	3
Arthritis, diabetes, digestive & kidney diseases	369.4	368.2	369.5	341.2	302.7	0
General medical sciences	345.6	339.9	333.7	312.5	277.3	2
Neurological, communicative disorders & stroke	274.5	265.9	252.5	242.0	212.1	3
Allergy & infectious diseases	246.0	235.9	232.1	215.4	191.9	4
Child health & human development	233.6	226.3	220.6	208.9	197.3	3
Environmental health sciences	157.4	106.3	93.5	83.9	80.6	3
Eye	131.5	127.4	118.0	113.0	104.8	1
Aging	84.6	81.9	75.6	70.0	56.5	48
Dental research	74.4	72.0	71.1	68.3	64.4	3
Research Resources	**191.0**	**184.2**	**175.6**	**169.2**	**158.7**	4
National Library of Medicine	**46.0**	**44.4**	**44.7**	**44.0**	**41.5**	4
Office of the Director	**24.3**	**22.5**	**22.5**	**21.0**	**30.6**	8
Research facilities	**17.5**	**21.5**	**17.0**	**50.0**	**30.3**	−19
John E. Fogarty Center	**10.1**	**9.2**	**9.1**	**9.0**	**9.4**	10
TOTAL	**$3738.4**	**$3651.8**	**$3574.5**	**$3475.7**	**$3205.3**	2%

a Administration request. b Estimate. c Based on Administration request. **Note:** Fiscal years.

OBLIGATIONS FOR PHYSICAL SCIENCE RESEARCH: Energy provides most for chemistry

	Federal obligations ($ millions)									
	1982[a]		1981[a]		1980		1979		1978	
Department or agency	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry	Physical sciences	Chemistry
Agriculture	$ 66.3	$ 61.7	$ 59.9	$ 55.7	$ 52.6	$ 48.9	$ 50.6	$ 47.2	$ 52.1	$ 47.8
Science & Education Administration	61.0	57.9	55.1	52.3	48.2	45.8	46.8	44.2	47.1	44.4
Commerce	45.6	11.1	42.3	10.0	38.7	9.5	35.5	8.9	32.5	8.2
National Bureau of Standards	39.2	9.7	36.5	8.8	32.3	8.7	29.8	7.7	27.5	7.1
Defense	671.8	107.7	506.6	89.3	410.5	78.2	385.4	97.6	358.4	71.3
Air Force	84.5	26.8	76.5	25.0	66.3	22.9	120.1	29.6	94.4	22.7
Army	133.7	48.3	103.1	38.8	100.3	36.9	90.2	51.0	84.2	30.1
Navy	223.5	32.0	182.6	25.0	131.0	17.6	106.2	16.2	100.6	17.8
Energy	1068.5	127.4	902.6	100.0	792.1	84.3	663.4	72.3	615.8	76.1
Environmental Protection Agency	70.1	70.1	82.9	82.9	71.5	70.7	73.2	72.5	70.7	67.8
Health & Human Services	90.3	79.2	83.8	73.4	79.8	69.9	69.8	62.8	58.3[b]	52.5[b]
National Institutes of Health	88.7	77.6	82.5	72.2	78.3	68.4	69.2	62.1	57.1	51.2
Interior	15.8	11.7	15.0	10.8	13.9	9.8	15.7	11.8	18.9	15.2
Geological Survey	8.1	6.1	8.0	6.0	6.2	4.6	6.6	4.9	13.2	11.1
National Aeronautics & Space Administration	337.4	6.0	295.8	7.6	321.3	6.7	304.8	6.4	264.8	9.3
National Science Foundation	261.0	90.5	225.8	76.9	203.2	70.7	205.8	65.6	195.7	60.3
Tennessee Valley Authority	3.3	3.3	3.2	3.2	3.1	3.1	5.4	5.4	5.4	5.4
Others	14.4	1.4	15.8	3.1	14.3	2.7	11.9	2.6	10.8	1.7
TOTAL	$2644.5	$570.1	$2233.7	$512.9	$2001.0	$454.5	$1821.5	$453.1	$1683.4	$415.6

a Estimated. b For Department of Health, Education & Welfare. **Note:** Fiscal years. **Source:** National Science Foundation

UNIVERSITY RESEARCH: Physical sciences get 15% of federal funds

								Annual change	
Federal obligations, $ millions	1982[a]	1981[a]	1980	1979	1978	1977	1976	1981–82	1976–82
Engineering	$ 403.6	$ 351.1	$ 323.7	$ 276.9	$ 247.0	$ 249.3	$ 191.9	15%	13%
Chemical	26.3	24.3	20.2	22.7	27.0	17.5	16.3	8	8
Metallurgy and materials	85.1	70.2	57.3	51.1	48.6	48.0	46.0	21	11
Environmental sciences	336.0	314.3	297.0	275.0	225.7	205.7	170.7	7	12
Life sciences	2278.9	2114.9	1984.7	1797.6	1606.1	1405.2	1233.6	8	11
Mathematics and computer sciences	142.8	117.1	[illegible]	86.7	78.9	69.8	67.0	22	13
Physical sciences	581.1	512.4	461.0	402.6	366.2	323.4	281.3	13	13
Chemistry	202.3	176.4	159.5	139.3	122.8	147.1	99.1	15	13
Physics	313.3	273.4	246.1	215.5	198.9	163.5	147.2	15	13
Other sciences	278.9	301.4	302.7	285.2	252.3	228.4	227.5	−7	4
TOTAL	$4021.3	$3711.2	$3483.9	$3124.0	$2776.2	$2482.2	$2172.0	8%	11%

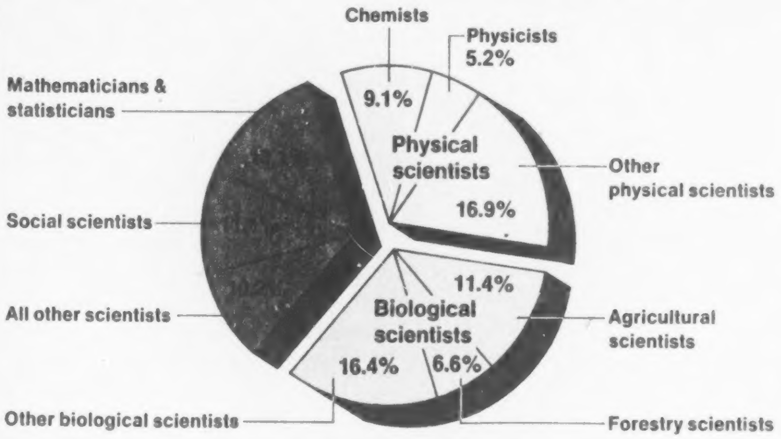
a Estimated. **Note:** Fiscal years. **Source:** National Science Foundation

UNIVERSITY BASIC RESEARCH: Federal funding for chemistry will be up 15% this year

								Annual change	
Federal obligations, $ millions	1982[a]	1981[a]	1980	1979	1978	1977	1976	1981–82	1976–82
Engineering	$ 289.1	$ 237.9	$ 208.4	$ 157.1	$ 147.1	$ 134.1	$ 109.8	21%	17%
Chemical	18.7	15.5	15.1	12.5	9.4	9.5	10.2	21	11
Metallurgy and materials	76.8	63.2	51.9	45.9	42.9	41.2	34.9	21	14
Environmental sciences	296.1	273.8	255.3	228.8	190.2	165.6	127.6	8	15
Life sciences	1428.9	1318.0	1219.5	1138.9	925.9	571.1	508.0	8	19
Mathematics and computer sciences	116.3	96.7	79.8	66.9	63.7	55.7	46.1	20	17
Physical sciences	482.9	420.5	375.9	320.0	296.9	273.8	243.1	15	12
Chemistry	175.6	152.2	136.1	112.8	100.9	101.7	88.1	15	12
Physics	252.2	217.1	194.3	164.6	155.8	135.7	125.2	16	12
Other sciences	152.3	151.2	126.4	124.5	102.3	91.6	78.3	1	12
TOTAL	$2765.6	$2498.1	$2265.3	$2036.2	$1726.1	$1291.9	$1112.9	11%	16%

a Estimated. **Note:** Fiscal years. **Source:** National Science Foundation

Chemists constitute about 9% of all federal scientists



1980 total federal scientists = 88,440[a]

[a] As of October 1980. **Source:** National Science Foundation

SCIENTISTS AND ENGINEERS BY AGENCY: Biggest field for government chemists is health

Department or agency	Physical scientists	Chemists	Physicists	Engineers	Chemical engineers	Other scientists	Total scientists and engineers
Agriculture	1,443	942	31	2,711	59	20,573	24,727
Commerce	3,902	351	602	903	23	3,403	8,208
Defense	8,653	1948	3311	54,450	704	12,568	75,671
Air Force	1,083	291	500	9,501	40	1,436	12,020
Army	3,124	873	890	19,728	382	4,495	27,347
Navy	3,858	699	1898	23,955	276	2,768	30,581
Others	588	85	23	1,266	6	3,869	5,723
Energy	920	273	126	2,813	205	689	4,422
Environmental Protection Agency	1,721	636	25	1,777	139	993	4,491
Health & Human Services	2,203	2041	93	494	25	5,282	7,979
Interior	4,989	472	64	3,113	85	6,960	15,062
National Aeronautics & Space Administration	1,362	86	282	9,032	38	822	11,216
Tennessee Valley Authority	259	121	0	3,880	180	401	4,540
Transportation	151	35	10	4,811	16	705	5,667
Veterans Administration	703	630	49	936	0	2,278	3,917
Others	1,314	548	41	4,564	40	6,146	12,124
TOTAL	27,620	8083	4634	89,584	1514	60,820	178,024

Note: Data as of October 1980. **Source:** National Science Foundation

FEDERAL SCIENTISTS AND ENGINEERS: Total has increased 11% in a decade

Thousands	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970
Physical scientists	27.6	27.6	27.5	27.1	27.1	26.7	26.3	26.4	27.4	30.4	29.8
Chemists	8.1	8.1	8.3	8.0	8.1	8.0	7.8	8.0	8.4	8.3	8.1
Physicists	4.6	4.9	5.0	5.1	5.3	5.4	5.5	5.6	5.8	5.4	5.4
Engineers	89.6	88.8	89.2	87.8	87.0	86.6	82.5	84.3	87.0	84.2	83.0
Chemical	1.5	1.5	1.5	1.4	1.4	1.4	1.4	1.5	1.6	1.5	1.4
Other scientists	60.8	58.3	57.2	54.3	51.6	50.6	48.8	48.4	50.1	48.7	47.4
TOTAL	178.0	174.7	173.9	169.2	165.7	163.9	157.6	159.1	164.5	163.3	160.2

Note: As of October of each year. **Source:** National Science Foundation

3 R&D

SECTION THREE
Industry

Healthy growth continues in industrial R&D

Spending on R&D last year by chemical producers was up about 18%, the best growth for any year in the past decade and well ahead of rising costs

TOTAL FUNDS FOR INDUSTRIAL R&D: Chemical firms hike outlays at better-than-average rate

$ Millions	1981[a]	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971	Annual change 1980–81	Annual change 1971–81
Chemicals and allied products	$ 5,420	$ 4,608	$ 4,033	$ 3,584	$ 3,256	$ 3,017	$ 2,727	$ 2,450	$ 2,116	$ 1,932	$ 1,832	18%	11%
Industrial chemicals	2,700	2,273	2,023	1,835	1,685	1,524	1,391	1,299	1,119	1,031	1,009	19	10
Drugs	1,950	1,665	1,445	1,270	1,154	1,091	981	807	698	607	549	17	14
Other chemicals	770	670	565	479	417	401	354	344	299	294	274	15	11
Other industries	44,180	39,271	34,114	29,781	26,672	23,980	21,460	20,437	19,133	17,620	16,488	13	10
TOTAL	$49,600	$43,879	$38,147	$33,365	$29,928	$26,997	$24,187	$22,887	$21,249	$19,552	$18,320	13%	10%

a C&EN estimates. **Source:** National Science Foundation

FEDERAL FUNDS FOR INDUSTRIAL R&D: Chemical industry receives only 3%

$ Millions	1981[a]	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971	Annual change 1980–81	Annual change 1971–81
Chemicals and allied products	$ 450	$ 407	$ 378	$ 366	$ 300	$ 266	$ 236	$ 214	$ 203	$ 189	$ 184	11%	9%
Industrial chemicals	425	386	360	347	284	249	218	194	183	171	159	10	10
Drugs and other chemicals	25	21	18	19	16	17	18	20	20	18	25	19	0
Other industries	15,300	13,532	12,114	10,843	10,221	9295	8369	8006	7942	7828	7482	13	7
TOTAL	$15,750	$13,939	$12,492	$11,209	$10,521	$9561	$8605	$8220	$8145	$8017	$7666	13%	7%

a C&EN estimates. **Source:** National Science Foundation

COMPANY FUNDS FOR INDUSTRIAL R&D: Industry boosts its R&D spending

$ Millions	1981[a]	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971	Annual change 1980–81	Annual change 1971–81
Chemicals and allied products	$ 4,970	$ 4,201	$ 3,655	$ 3,218	$ 2,956	$ 2,751	$ 2,490	$ 2,236	$ 1,913	$ 1,741	$ 1,648	18%	12%
Industrial chemicals	2,275	1,887	1,633	1,488	1,402	1,275	1,173	1,105	936	860	850	20	10
Drugs and other chemicals	2,695	2,314	2,022	1,730	1,554	1,476	1,317	1,131	977	881	798	16	14
Other industries	28,800	25,739	22,000	18,938	16,451	14,685	13,092	12,431	11,191	9,794	9,006	12	12
TOTAL	$33,850	$29,940	$25,655	$22,156	$19,407	$17,436	$15,582	$14,667	$13,104	$11,535	$10,654	13%	12%

a C&EN estimates. **Source:** National Science Foundation

COMPANY R&D SPENDING: Budgets up sharply in 1982 for fourth year

$ Millions	1982[a]	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972
Air Products	$ 35	$ 32	$ 30	$ 24	$ 23	$ 24	$ 19	$ 16	$ 11	$ 8	$ 7
Akzona	36	32	28	25	23	20	18	17	16	13	11
Allied	198	152	105	70	56	51	40	35	31	29	29
American Cyanamid	180	164	142	124	108	96	83	73	64	52	44
Celanese	118	104	94	92	83	77	70	64	58	49	52
Diamond Shamrock	64	53	45	37	32	26	24	20	14	12	12
Dow Chemical	500	404	314	269	232	203	188	167	149	118	105
Du Pont[b]	670	575	485	415	377	367	353	336	344	286	265
W. R. Grace	65	55	45	42	37	32	28	30	32	28	22
Hercules	66	61	53	47	40	37	35	30	30	25	24
Monsanto[c]	260	221	204	161	136	132	114	116	87	82	92
Pennwalt	34	27	24	22	23	21	19	16	14	13	18
Rohm & Haas	90	77	67	54	49	45	43	45	39	32	25
Stauffer Chemical	60	51	44	37	34	33	29	24	20	17	14
Union Carbide	222	201	166	161	156	156	143	120	94	77	70
TOTAL	**$2598**	**$2209**	**$1846**	**$1580**	**$1409**	**$1320**	**$1206**	**$1109**	**$1003**	**$841**	**$790**
ANNUAL CHANGE	**18%**	**20%**	**17%**	**12%**	**7%**	**9%**	**9%**	**11%**	**19%**	**6%**	**2%**

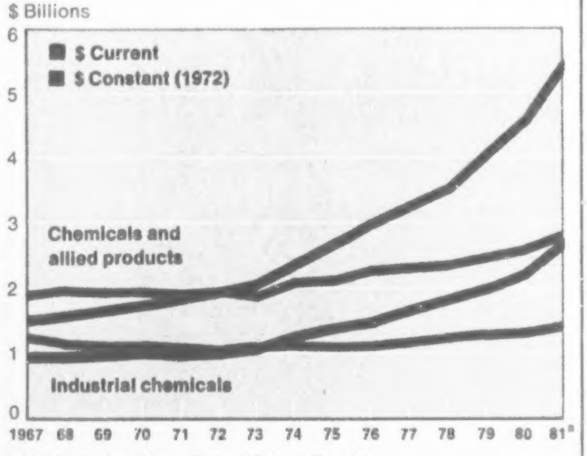
a Planned. b Excludes Conoco. c R&D definition narrowed after 1972. **Sources:** Company data, C&EN estimates

R&D BY U.S. COMPANIES ABROAD: Chemical firms step up spending overseas

$ Millions	1981[a]	1980	1979	1978	1977	1976	1975	1974	Annual change 1980–81	Annual change 1974–81
Chemicals and allied products	**$ 700**	**$ 613**	**$ 505**	**$ 399**	**$ 332**	**$ 312**	**$ 269**	**$ 208**	14%	13%
Industrial and other chemicals	280	249	201	153	133	108	85	82	12	13
Drugs	420	364	304	246	199	204	184	126	15	13
Other industries	**2800**	**2583**	**2277**	**1810**	**1545**	**1347**	**1185**	**1092**	**8**	**10**
TOTAL	**$3500**	**$3196**	**$2782**	**$2209**	**$1877**	**$1659**	**$1454**	**$1300**	10%	10%

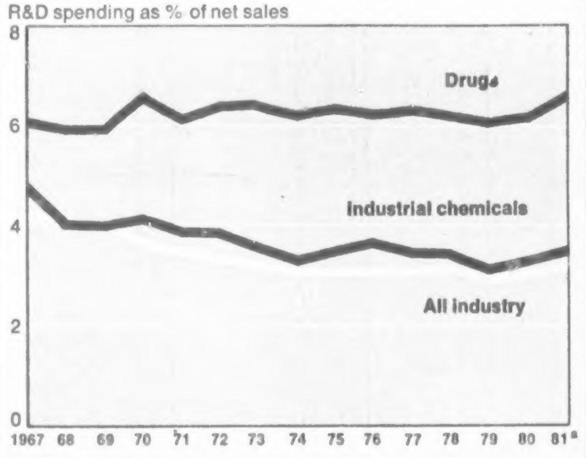
a C&EN estimates. **Source:** National Science Foundation

R&D spending in chemical industry has been outpacing inflation since mid-1970s



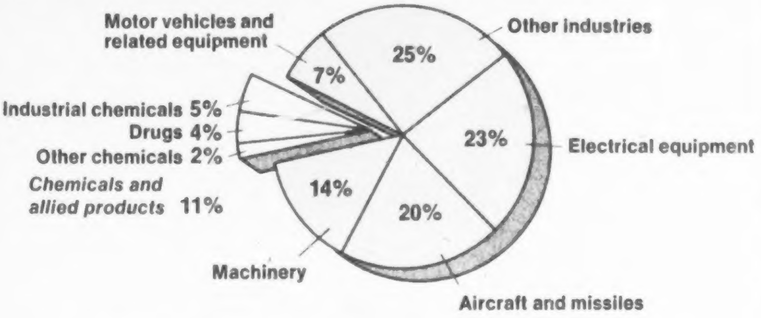
a C&EN estimates. **Source:** National Science Foundation

Outlays for R&D have been rising faster than company sales in past two years



a C&EN estimates. **Source:** National Science Foundation

Chemical industry, overall, employs 11% of all scientists and engineers in industrial R&D



1981 total industrial R&D scientists and engineers[a] = 470,200

[a] Full-time equivalent. **Source:** National Science Foundation

R&D SCIENTISTS AND ENGINEERS PER 1000 EMPLOYEES: Chemical producers rank high

	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969
Chemicals and allied products	**41**	**40**	**42**	**42**	**40**	**41**	**40**	**39**	**39**	**41**	**39**	**35**
Industrial chemicals	36	36	38	38	36	38	37	36	34	35	35	32
Drugs	61	61	64	62	64	59	57	57	60	65	65	48
Other chemicals	29	27	26	28	28	29	30	29	31	31	30	31
All industry	**29**	**29**	**28**	**27**	**27**	**26**	**25**	**24**	**24**	**26**	**26**	**26**

Source: National Science Foundation

COST PER INDUSTRIAL R&D SCIENTIST OR ENGINEER: Tops $100,000 for chemical firms

$ Thousands	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970
Chemicals and allied products	**$ 89.6**	**$81.4**	**$73.9**	**$69.1**	**$66.5**	**$60.9**	**$56.3**	**$51.1**	**$47.1**	**$43.7**	**$42.8**
Industrial chemicals	104.7	94.3	85.2	80.0	74.7	67.5	63.5	58.6	54.0	49.2	47.5
Drugs	81.0	72.8	65.8	65.0	63.4	60.9	54.3	51.5	46.5	43.2	40.1
Other chemicals	73.2	68.5	63.0	54.2	50.8	43.2	45.3	34.0	33.4	35.5	33.4
All industry	**95.7**	**87.7**	**80.7**	**76.1**	**72.2**	**66.5**	**63.3**	**59.2**	**55.3**	**51.1**	**48.1**

Source: National Science Foundation

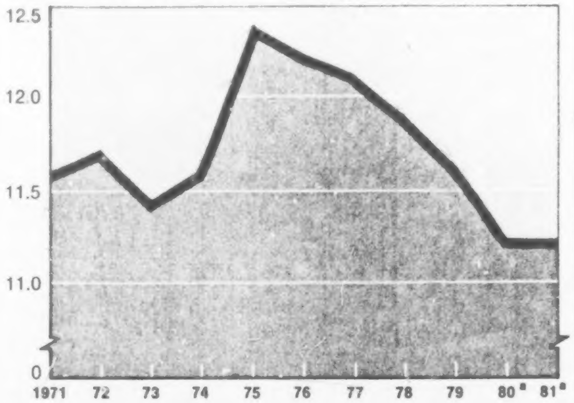
CHEMISTS IN INDUSTRY: More than half work for chemical or drug makers

	% of industrial chemicals			
Industry	**All chemists**	**B.S.**	**M.S.**	**Ph.D.**
Chemical	35%	31%	30%	40%
Pharmaceutical	17	14	20	17
Petroleum	6	5	4	8
Coatings	5	7	5	3
Food	4	5	5	3
Metals and minerals	3	4	3	2
Rubber	2	4	3	1
Paper	1	1	1	2
Other manufacturing	20	21	22	19
Nonmanufacturing	6	8	7	5

Source: 1982 ACS survey

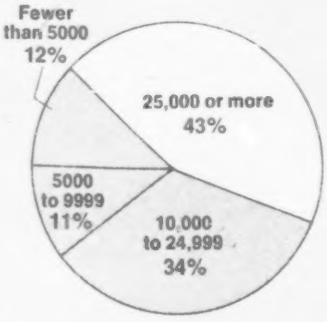
Jobs for scientists in chemical industry have declined relatively since mid-'70s

% of industrial R&D scientists and engineers[a] in the chemicals and allied products industry

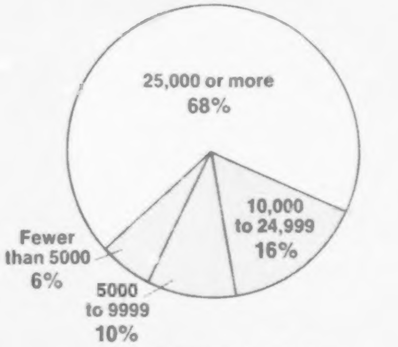


[a] Full-time equivalent. **Source:** National Science Foundation

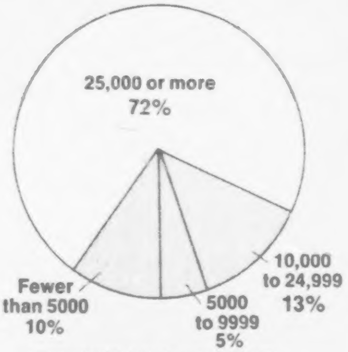
Most R&D funds are spent by companies with greatest total employment



Total 1980 chemicals and allied products R&D funds = $4.6 billion



Total 1980 industrial chemicals R&D funds = $2.3 billion



Total 1980 industry R&D funds = $43.9 billion

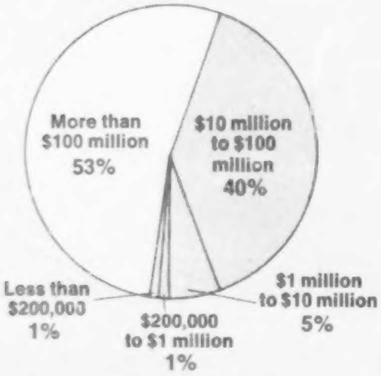
Note: Ranges indicate company's number of employees in 1980. **Source:** National Science Foundation

R&D SCIENTISTS AND ENGINEERS IN INDUSTRY: More than 10% work in chemical industry

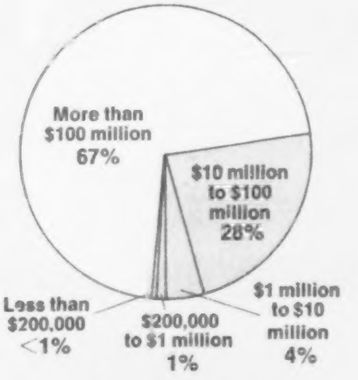
Thousands[a]	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971
Chemicals and allied products	**52.8**	**50.0**	**49.1**	**47.9**	**46.4**	**44.4**	**45.2**	**41.8**	**40.9**	**41.0**	**42.7**
Industrial chemicals	22.1	21.3	21.6	21.5	20.6	20.1	21.1	19.1	19.1	19.1	21.8
Drugs	21.1	20.0	19.7	18.9	17.8	16.6	15.6	14.0	13.0	13.1	12.3
Other chemicals	9.6	9.7	7.8	7.4	8.0	7.8	8.5	8.7	8.8	8.8	8.6
Other industries	**417.4**	**396.6**	**374.1**	**355.8**	**336.4**	**320.0**	**318.1**	**318.2**	**316.8**	**309.2**	**324.3**
TOTAL	**470.2**	**446.6**	**423.2**	**403.7**	**382.8**	**364.4**	**363.3**	**360.0**	**357.7**	**350.2**	**367.0**

a Full-time equivalent. **Source:** National Science Foundation

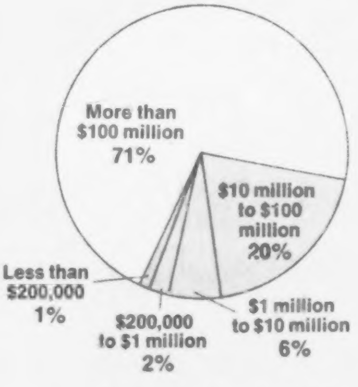
Firms with R&D budgets under $10 million account for less than 10% of total R&D spending



Total 1980 chemicals and allied products R&D funds = $4.6 billion



Total 1980 industrial chemicals R&D funds = $2.3 billion



Total 1980 industry R&D funds = $43.9 billion

Note: Ranges indicate size of company's 1980 R&D program. **Source:** National Science Foundation

Academic R&D shows moderate growth

Basic research accounts for most academic R&D, but its share of the total spending has dropped from 77% to 66% since 1971

CHARACTER OF UNIVERSITY R&D SPENDING: Basic research's share down to 66%

$ Millions	1981[a]	1980	1979	1978[b]	1977	1976	1975	1974	1973	1972	1971	Annual change 1980-81	Annual change 1971-81
Basic research	$4385	$4019	$3607	$3172	$2802	$2548	$2410	$2154	$2053	$2022	$1914	9%	9%
Applied research	1840	1687	1463	1213	1068	1015	851	736	713	524	474	9	15
Development	375	343	284	236	200	164	148	133	118	84	112	9	13
TOTAL	**$6600**	**$6049**	**$5354**	**$4621**	**$4070**	**$3727**	**$3409**	**$3023**	**$2884**	**$2630**	**$2500**	9%	10%

a Estimates. **b** Estimated, based on data from Ph.D.-granting institutions only. **Note:** Data for institutional fiscal years. **Source:** National Science Foundation

SOURCE OF UNIVERSITY R&D FUNDS: Institutions' own share is growing most rapidly

$ Millions	1981[a]	1980	1979	1978[b]	1977	1976	1975	1974	1973	1972	1971	Annual change 1980-81	Annual change 1971-81
Federal government	$4400	$4093	$3594	$3057	$2730	$2512	$2288	$2032	$1985	$1795	$1724	8%	10%
State and local governments	550	492	469	414	373	363	332	307	295	270	255	12	8
Industry	260	236	193	170	139	123	113	96	84	74	70	10	13
Institutional funds	940	821	725	622	514	445	417	370	318	305	274	14	13
Other sources	450	408	373	359	315	285	259	218	202	187	177	10	10
TOTAL	**$6600**	**$6049**	**$5354**	**$4621**	**$4070**	**$3727**	**$3409**	**$3023**	**$2884**	**$2630**	**$2500**	9%	10%

a Estimates. **b** Estimated, based on data from Ph.D.-granting institutions only. **Note:** Data for institutional fiscal years. **Source:** National Science Foundation

FIELDS OF UNIVERSITY R&D SPENDING: Chemistry's share is 4% of the total

$ Millions	1981[a]	1980	1979	1978[b]	1977	1976	1975	1974	1973	1972	1970	Annual change 1980-81	Annual change 1970-81
Physical sciences	**$ 740**	**$ 679.7**	**$ 603.3**	**$ 496.4**	**$ 428.4**	**$ 379.4**	**$ 350.3**	**$ 333.5**	**$ 328.3**	**$ 324.2**	**$ 307.3**	9%	8%
Chemistry	270	245.6	207.7	183.2	164.3	140.1	120.7	115.8	113.7	108.1	102.0	10	9
Physics	355	329.2	300.8	235.1	201.7	183.1	173.5	169.2	167.0	159.1	161.9	8	8
Engineering	**970**	**862.6**	**767.8**	**601.1**	**498.5**	**431.7**	**380.9**	**346.9**	**333.1**	**341.4**	**318.8**	12	11
Total R&D spending	**6600**	**6049.3**	**5354.4**	**4621.3**	**4069.8**	**3727.2**	**3408.6**	**3022.6**	**2884.0**	**2630.4**	**2334.9**	9	10

a C&EN estimates. **b** NSF estimates, based on data from Ph.D.-granting institutions only. **Note:** Data for institutional fiscal years; 1971 not available. **Source:** National Science Foundation

FEDERALLY FINANCED R&D SPENDING AT UNIVERSITIES: Growth last year below average

$ Millions	1981[a]	1980	1979	1978[b]	1977	1976	1975	1974	1973	1972	1970	Annual change 1980-81	Annual change 1970-81
Physical sciences	**$ 600**	**$ 555.3**	**$ 491.1**	**$ 392.3**	**$ 342.8**	**$ 305.4**	**$ 285.0**	**$ 270.2**	**$ 268.4**	**$ 261.0**	**$ 257.8**	8%	8%
Chemistry	205	189.3	157.0	138.0	125.4	107.9	92.7	88.7	86.6	82.6	78.9	8	9
Physics	305	286.9	261.4	199.2	171.9	156.1	149.9	146.5	145.4	136.3	144.3	6	8
Engineering	**660**	**594.5**	**526.4**	**407.5**	**336.7**	**290.5**	**259.4**	**239.3**	**238.1**	**252.9**	**245.9**	11	9
Total R&D spending	**4400**	**4092.6**	**3594.4**	**3057.2**	**2729.8**	**2511.6**	**2288.1**	**2032.2**	**1985.4**	**1795.0**	**1647.5**	8	9

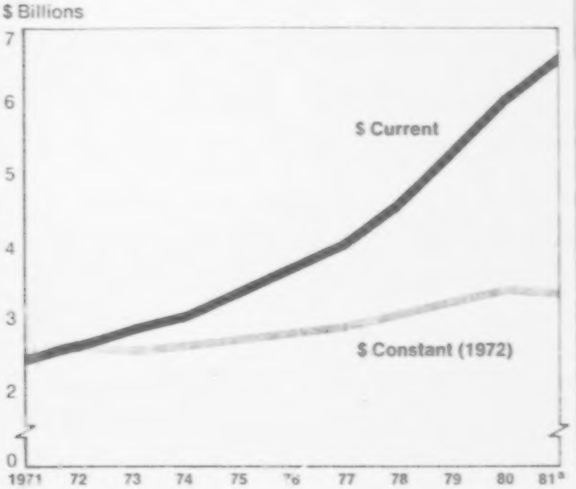
a C&EN estimates. **b** NSF estimates, based on data from Ph.D.-granting institutions only. **Note:** Data for institutional fiscal years; 1971 not available. **Source:** National Science Foundation

TOP 12 UNIVERSITIES IN R&D SPENDING: Johns Hopkins has largest science outlays

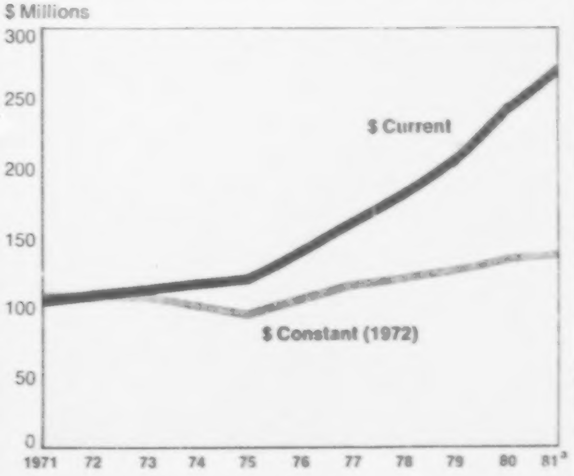
$ Millions, fiscal 1980	Physical sciences	Chemistry[a]	Engineering	Environmental sciences	Life sciences	Math and computer sciences	Other sciences[b]	Total
Johns Hopkins University	$48.2	$4.7	$55.3	$28.4	$70.1	$42.0	$ 8.6	**$253.2**
Massachusetts Institute of Technology	46.4	6.8	69.6	8.9	20.7	9.0	9.1	**163.6**
University of Wisconsin, Madison	15.8	6.6	11.3	13.1	70.7	4.6	22.7	**138.2**
University of California, San Diego	20.1	4.5	2.0	60.0	39.7	0.7	2.3	**124.8**
University of Minnesota	6.6	2.6	9.3	2.2	90.7	1.4	9.0	**119.1**
Stanford University	17.3	4.8	33.3	2.3	46.8	7.1	6.2	**113.1**
University of Washington	5.4	1.3	5.4	16.4	70.6	0.9	13.1	**111.9**
University of Michigan	6.5	2.1	15.2	12.1	50.7	1.7	25.1	**111.3**
Cornell University	17.2	3.8	14.3	3.4	62.4	1.5	8.8	**107.6**
Columbia University, main division	10.4	4.4	7.7	17.9	58.2	0.6	6.6	**101.4**
Harvard University	13.4[c]	4.8[c]	2.8[c]	5.5[c]	66.6[c]	1.8[c]	10.7[c]	**100.9[c]**
University of Pennsylvania	9.1	3.7	4.4	0.7	58.8	3.5	17.7	**94.2**

a Included in physical sciences. **b** Includes social sciences, psychology, and other sciences not listed separately. **c** Estimate. **Source:** National Science Foundation

Total outlay for academic R&D, in real terms, generally is up from early 1970s...



...and spending for academic R&D in chemistry has fared even better since 1975



a Estimate. **Note:** Data for institutional fiscal years. **Source:** National Science Foundation

TOP 12 UNIVERSITY R&D CENTERS:[a] Most funding goes for physical science

$ Millions, fiscal 1980	Physical sciences	Engineering	Environmental sciences	Life sciences	Total[b]
Lawrence Livermore National Lab	$286.0	$ 52.1	$35.9	$ 3.3	**$401.1**
Jet Propulsion Lab	65.5	201.6	16.6	4.2	**385.5**
Los Alamos National Lab	178.1	120.0	8.2	13.9	**375.4**
Argonne National Lab	84.6	134.8	50.3	14.2	**286.7**
Brookhaven National Lab	80.8	21.9	9.2	17.5	**137.7**
Lincoln Lab	26.6	95.2	0	0	**135.0**
Lawrence Berkeley Lab	70.3	12.8	25.0	18.6	**130.6**
Plasma Physics Lab	126.0[c]	0	0	0	**126.0[c]**
Fermi National Accelerator Lab	83.2	0	0	0	**83.2**
Stanford Linear Accelerator Center	66.5	0	0	0	**66.5**
National Center for Atmospheric Research	5.9	0	28.0	0	**33.9**
Ames Laboratory	11.3	5.2	0.1	0	**16.7**

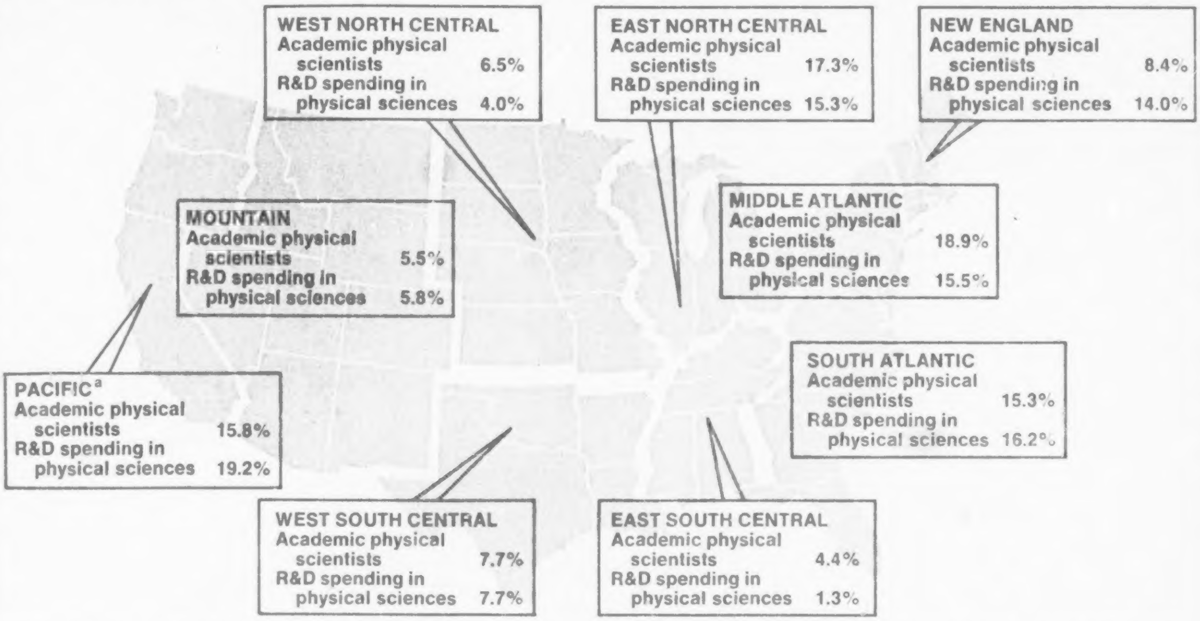
a Data for university-administered federally funded R&D centers. **b** Includes sciences not listed separately. **c** Estimate. **Source:** National Science Foundation

ACADEMIC SCIENTISTS AND ENGINEERS: Employment of chemists up 3% last year

Thousands of scientists and engineers[a]	1981	1980	1978	1977	1976	1975	1974
TOTAL							
Physical scientists	**34.1**	**33.6**	**32.8**	**32.1**	**31.4**	**30.8**	**30.6**
Chemists	18.1	17.6	17.7	17.1	16.6	16.2	16.1
Physicists	12.9	13.0	12.8	12.5	12.2	12.3	12.1
Engineers	**34.8**	**33.7**	**31.0**	**30.1**	**28.5**	**27.9**	**27.2**
Chemical	2.3	2.4	2.0	1.9	1.9	1.9	1.7
Other scientists	**264.6**	**256.8**	**243.8**	**235.5**	**228.3**	**220.2**	**210.7**
TOTAL	**333.4**	**324.1**	**307.6**	**297.8**	**288.2**	**278.9**	**268.5**
FULL-TIME ONLY							
Physical scientists	**28.2**	**28.0**	**27.9**	**27.6**	**27.1**	**26.7**	**26.8**
Chemists	14.8	14.3	14.7	14.5	14.1	13.8	14.1
Physicists	11.0	11.3	11.2	11.1	10.8	10.9	10.9
Engineers	**27.0**	**26.5**	**24.7**	**24.1**	**22.9**	**22.6**	**22.8**
Chemical	1.9	1.9	1.7	1.7	1.6	1.6	1.5
Other scientists	**203.7**	**200.4**	**189.5**	**184.5**	**179.8**	**174.1**	**168.8**
TOTAL	**258.8**	**254.9**	**242.1**	**236.2**	**229.8**	**223.3**	**218.4**

a In January. **Note:** Data not available for 1979. **Source:** National Science Foundation

Nearly two thirds of academic physical scientists and academic R&D in physical science are east of the Mississippi



WEST NORTH CENTRAL
Academic physical scientists 6.5%
R&D spending in physical sciences 4.0%

EAST NORTH CENTRAL
Academic physical scientists 17.3%
R&D spending in physical sciences 15.3%

NEW ENGLAND
Academic physical scientists 8.4%
R&D spending in physical sciences 14.0%

MOUNTAIN
Academic physical scientists 5.5%
R&D spending in physical sciences 5.8%

MIDDLE ATLANTIC
Academic physical scientists 18.9%
R&D spending in physical sciences 15.5%

PACIFIC[a]
Academic physical scientists 15.8%
R&D spending in physical sciences 19.2%

SOUTH ATLANTIC
Academic physical scientists 15.3%
R&D spending in physical sciences 16.2%

WEST SOUTH CENTRAL
Academic physical scientists 7.7%
R&D spending in physical sciences 7.7%

EAST SOUTH CENTRAL
Academic physical scientists 4.4%
R&D spending in physical sciences 1.3%

Key to map: Using the Middle Atlantic states as an example, 18.9% of all physical scientists employed at universities and colleges are located in this geographical area and 15.5% of all R&D expenditures in the physical sciences by universities and colleges are in this area. **a** Includes Alaska and Hawaii. **Note:** Data are based on 33,694 physical scientists employed at universities and colleges in the U.S. as of January 1981, and R&D expenditures of $679.2 million in the physical sciences during these institutions' 1980 fiscal year; data exclude universities and colleges in outlying areas. **Source:** National Science Foundation

CHEMICAL DEGREES: Engineering degrees increase, but those in chemistry decline a bit

Academic year	Degrees awarded in chemistry[a]			Degrees awarded in chemical engineering		
	Bachelors	Masters	Ph.D.s	Bachelors	Masters	Ph.D.s
1965-66	9,735	1839	1571	2848	994	354
1966-67	9,872	1831	1744	2869	949	305
1967-68	10,847	2014	1757	3211	1156	367
1968-69	11,807	2070	1941	3557	1136	409
1969-70	11,617	2146	2208	3720	1045	438
1970-71	11,183	2284	2160	3615	1100	406
1971-72	10,721	2259	1971	3663	1154	394
1972-73	10,226	2230	1882	3636	1051	397
1973-74	10,525	2138	1828	3454	1045	400
1974-75	10,649	2006	1824	3142	990	346
1975-76	11,107	1796	1623	3203	1031	308
1976-77	11,322	1775	1571	3581	1086	291
1977-78	11,474	1892	1525	4615	1237	259
1978-79	11,643	1765	1518	5655	1149	304
1979-80	11,446	1733	1551	6383	1271	284

a Does not include biochemistry and geochemistry. **Source:** Department of Education's National Center for Education Statistics

GRADUATE SCIENCE STUDENTS: Engineering outgains physical sciences

Thousands	1980	1979	1978	1977	1976	1975	1974
TOTAL							
Physical sciences	25.4	24.9	24.7	24.9	24.8	24.6	24.5
Chemistry	15.1	14.9	14.8	14.6	14.4	14.1	13.7
Physics	9.6	9.3	9.2	9.5	9.7	9.7	10.0
Engineering	72.3	68.9	65.8	65.8	64.2	64.6	56.6
Chemical	6.1	5.6	5.3	5.2	5.2	5.1	4.7
Metallurgical and materials	2.8	2.6	2.5	2.5	2.3	2.3	2.2
Petroleum	0.5	0.4	0.4	0.4	0.4	0.3	0.3
Biological sciences	42.1	42.1	42.7	42.7	41.6	40.6	37.6
Biochemistry	[illegible]	3.8	3.9	3.8	3.7	3.7	3.7
Other sciences[a]	[illegible]	184.7	176.6	173.1	167.5	163.9	146.6
TOTAL	333.7	320.5	309.8	306.5	298.1	293.8	265.3
FULL-TIME ONLY							
Physical sciences	22.3	21.8	21.5	21.8	21.6	21.3	21.3
Chemistry	13.1	12.8	12.7	12.6	12.4	12.0	11.8
Physics	8.5	8.3	8.2	8.5	8.5	8.5	8.8
Engineering	42.5	39.8	37.4	37.1	36.5	37.1	33.6
Chemical	4.6	4.3	4.0	4.0	3.8	3.6	3.3
Metallurgical and materials	2.2	2.1	1.9	1.9	1.8	1.8	1.6
Petroleum	0.4	0.3	0.3	0.3	0.3	0.2	0.2
Biological sciences	35.3	35.3	35.5	35.8	35.2	34.5	32.2
Biochemistry	3.6	3.5	3.6	3.5	3.4	3.4	3.5
Other sciences[a]	130.6	126.5	122.1	122.8	120.7	117.3	108.4
TOTAL	230.6	223.4	215.6	217.4	214.1	210.3	195.5

a Includes environmental, mathematical, health, agricultural, social sciences, psychology
Note: Data for Ph.D.-granting institutions only. **Source:** National Science Foundation

SCHOOLS SPENDING MOST ON CHEMICAL R&D: Top 50 account for nearly two thirds of total

$ Thousands	Total spending				Federally financed spending			
	1980	1979	1978	1977	1980	1979	1978	1977
1 Massachusetts Inst. of Technology	$ 6,764	$ 5,324	$ 6,242	$ 4,735	$ 6,311	$ 5,021	$ 5,837	$ 4,351
2 U of Wisconsin, Madison	6,643	5,450	5,149	5,136	3,779	2,865	2,933	2,880
3 California Inst. of Technology	6,328	5,297	4,108	5,143	5,630	4,813	3,712	4,322
4 U of California, Berkeley	6,022	3,717	3,046	3,090	5,601	3,485	2,758	2,742
5 Harvard U	4,797[a]	4,283[a]	3,905[a]	2,958	3,631	3,241	3,396	2,566
6 Stanford U	4,788	4,159	3,549[a]	2,659	4,609	3,775	3,266	2,581
7 Johns Hopkins U	4,652	4,064[a]	1,160	1,160	4,444	3,968[a]	1,034	1,102
8 U of California, San Diego	4,471	4,225	3,611	3,344	4,087	3,913	3,293	3,064
9 Columbia U, main division	4,437	3,531	3,321	2,975	4,054	3,202	2,854	2,747
10 U of Illinois, Urbana	4,261	3,963	3,211	2,438	3,424	2,696	2,426	2,045
Total, first 10 institutions	**53,163**	**44,013**	**37,302**	**33,638**	**45,570**	**36,979**	**31,559**	**28,400**
11 U of California, Los Angeles	4,159	3,573	3,236	2,563	4,017	3,379	3,052	2,408
12 Texas A&M U	4,097	3,715	3,261	3,894	2,945	2,361	2,243	2,205
13 U of Texas, Austin	3,970	3,373	3,057	2,361	2,564	2,282	1,931	1,286
14 U of Chicago	3,958[a]	3,418[a]	3,113[a]	2,789	3,558	3,039	2,803	2,684
15 Cornell U	3,808	3,414	3,423	3,048	3,404	3,087	3,137	2,888
16 U of Pennsylvania	3,688	2,211	1,761	973	3,143	1,840	1,356	762
17 Georgia Inst. of Technology	3,655	3,577	2,784	2,013	2,118	2,110	1,551	1,075
18 Purdue U	3,596	3,438	2,857	2,545	3,151	3,087	2,500	2,170
19 U of Notre Dame	3,457	2,746	2,475	2,560	3,328	2,618	2,389	2,461
20 U of Colorado	3,332	2,544	899	992	2,605	1,942	688	902
Total, first 20 institutions	**90,883**	**76,022**	**64,168**	**57,376**	**76,403**	**62,724**	**53,209**	**47,241**
21 Indiana U	3,147	2,644	2,234	1,616	2,635	2,306	1,959	1,484
22 Pennsylvania State U	2,973	2,303	1,904	1,452	2,527	1,989	1,590	1,309
23 U of Utah	2,811	2,290	2,754	7,149	2,373	1,949	1,909	5,636
24 Florida State U	2,791	2,478	1,490[b]	1,470	1,313	1,160	777[b]	727[a]
25 U of Maryland, College Park	2,766	1,907	1,975	1,389	2,292	1,628	1,690	959
26 Ohio State U	2,654	2,039	1,740	2,015	2,144	1,743	1,493	1,738
27 U of Minnesota	2,642	2,162	1,803	1,667	2,143	1,624	1,415	1,279
28 Northwestern U	2,367	1,851	1,854	1,250	2,221	1,671	1,681	1,068
29 U of Southern California	2,313	2,181	1,676	764	1,773	1,731	1,381	722
30 U of Nebraska, Lincoln	2,289	1,745	1,040	391	1,909	983	769	347
Total, first 30 institutions	**117,636**	**97,622**	**82,638**	**76,539**	**97,733**	**79,508**	**67,373**	**62,510**
31 U of Florida	2,283[a]	1,968	1,265	769	1,214[a]	1,339	1,077	686
32 Wayne State U	2,163	2,022	2,740	1,280	1,640	1,555	1,926	1,172
33 U of Rochester	2,089	2,536	2,100	1,987	1,667	2,056	1,695	1,519
34 Carnegie-Mellon U	2,075	1,957	3,828	4,425	1,515	1,403	1,542	1,079
35 Princeton U	2,065	2,242	1,660	1,508	1,646	1,621	1,271	1,113
36 U of Michigan	2,064	1,406	1,171	851	1,775	1,229	982	604
37 Yale U	2,023	2,107	1,444	1,532	1,886	1,750	1,379	1,455
38 Colorado State U	1,973	1,774	1,398	1,100	1,717	1,579	1,193	853
39 State U of New York, Stony Brook	1,966	1,801	1,637	1,201	1,632	1,554	1,281	1,050
40 Case Western Reserve U	1,938	1,413	1,190	1,119	1,617	1,145	940	973
Total, first 40 institutions	**138,275**	**116,848**	**101,071**	**92,391**	**114,042**	**94,739**	**81,159**	**73,[illegible]**
41 U of Massachusetts, Amherst	1,889	2,621	2,038	1,922	1,632	1,921	1,633	1,308
42 U of North Carolina, Chapel Hill	1,789	1,685	1,413	1,471	1,752	1,666	1,398	1,448
43 U of Arkansas, Fayetteville	1,674[a]	1,180[a]	1,765	249	370	281	295	217
44 State U of New York, Buffalo	1,665	1,143	1,008	966	1,163	817	735	894
45 U of Pittsburgh	1,641	1,728	1,709	1,542	1,366	1,416	1,201	1,328
46 Michigan State U	1,638	1,491	1,262	1,266	1,157	1,045	878	1,063
47 Virginia Polytechnic Inst. & State U	1,612	1,281	1,134[a]	987	1,047	875	714[a]	674
48 U of California, San Francisco	1,564	1,235	1,110	850	1,536[a]	1,201	976	792
49 Louisiana State U	1,561	1,161	1,204	927	873	620	635	661
50 Rensselaer Polytechnic Inst.	1,551	968	900	811	962	680[a]	660	605
TOTAL, FIRST 50 INSTITUTIONS	**$154,859**	**$131,341**	**$114,614**	**$103,382**	**$125,900**	**$105,261**	**$ 90,334**	**$ 82,004**
NATIONAL TOTAL	**$245,610**	**$207,674**	**$183,131**	**$164,302**	**$189,349**	**$156,950**	**$138,001**	**$125,440**

a Estimate. b Imputed. **Note:** Data for institutional fiscal years. **Source:** National Science Foundation

Chemical & Engineering NEWS

FINAL PROGRAM
ACS Kansas City meeting Page 26

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Phenol, vinyl acetate languish in housing slump

A Key Chemicals Review Page 9

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Chemical & Engineering NEWS

Cover: General Electric's phenol plant at Mount Vernon, Ind.

2 Letters

Concentrates
8 Business
16 Government
18 Science/Technology

The Departments
107 Meetings
109 Awards
110 People
122 Newscripts

News of the Week

- ***Senate-passed bill cuts back*** *a number of tax incentives, such as faster investment write-offs, for business.* ***Page 4***
- ***Increases in chemical prices*** *have not fared well lately; attempts to raise industrial gas prices may backfire.* ***Page 5***
- ***Perfluorocarbon emulsion*** *was an effective blood substitute in clinical trials of anemic patients undergoing surgery.* ***Page 5***
- ***No evidence of a fuel meltdown*** *was apparent in a camera inspection of the reactor core at Three Mile Island.* ***Page 5***
- ***A bacterial gene*** *that may be used to protect plants from freezing has been isolated by researchers in California.* ***Page 6***
- ***Edwin H. Land*** *steps down from posts at Polaroid Corp. to head nonprofit institute for fundamental research.* ***Page 6***

Business

- ***Adhesives intermediates hurt*** *by slow construction market; phenol dives, vinyl acetate proves stabler.* ***Page 9***

International

- ***Soviet Union faces severe problems*** *in economic, industrial, military spheres and an aging political leadership.* ***Page 14***
- ***Texturized polyester makers*** *look to developing countries for markets as cotton acreage is shifted to food crops.* ***Page 15***

Government

- ***President Reagan's environmental policy*** *calls for more flexible regulations, return of decision-making to states.* ***Page 17***

Science

- ***Gene that codes for a specific enzyme*** *sequence made with synthetic DNA.* ***Page 19***

Technology

- ***Mass spectrometer-based detector*** *designed for gas chromatographers.* ***Page 20***
- ***Seven new concepts*** *for fluidized-bed coal combustion will be assessed by the Department of Energy.* ***Page 21***

Education

- ***Eight charter member companies*** *join Texas A&M chemistry department in cooperative program for research, aid.* ***Page 21***

Books

- ***"Genetic Prophecy: Beyond the Double Helix"*** *points up use of genetics in medicine, perils of misuse of screening.* ***Page 23***

Final Program

- ***Complete technical program,*** *symposia guide, descriptions of trips and plant tours for Kansas City ACS meeting.* ***Page 26***

Phenol, vinyl acetate struggle through 1982

Recession has hurt both of these intermediates for adhesives; vinyl acetate shows more stability than badly slumping phenol

Bruce F. Greek
C&EN, Houston

Phenol and vinyl acetate both cost about 30 cents per lb in the real market, have their biggest use in adhesives, depend heavily on construction markets, and stop growing in recessions. They also are both organics, of course, with production close to 2 billion lb this year.

But that's about it for similarities. Vinyl acetate, the olefin, shows itself by far the sprightlier and stabler of the two, whereas phenol, the aromatic, careens through another of its market upsets in the wake of trouble in its dominant use in housing.

Key Chemicals

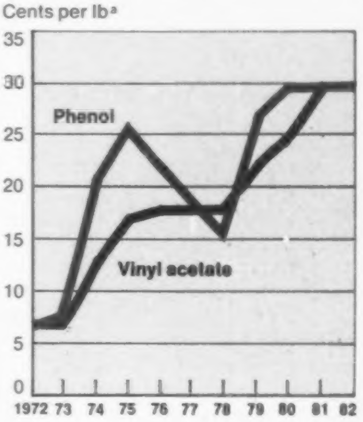
For all its ups and downs over the years, phenol actually has covered about the same net increase in value as has vinyl acetate with half the olefin's growth rate. From 1971 through 1981, phenol averaged a 4% gain in output per year, while vinyl acetate had one of the best records among major organics with 8%. Both more than quadrupled in price, reflecting the oil-price explosion.

For now, both likely will have the same or lower production in 1982 than in 1981. For 1983, prospects are for relatively small gains for each. Later, output for vinyl acetate could top its previous volume, but phenol's recovery will take much longer.

A close connection to housing and commercial construction largely explains why production of phenol and vinyl acetate peaked three years ago. Housing starts may total less than 1 million units for 1982, half the level of just a few years ago. High interest rates are the continuing problem. In the meantime, phenol and vinyl acetate cannot develop new uses in time to help near-term.

Of the two, phenol has the larger share of its markets in construction, especially residential and light commercial property. In addition, some of its other uses, such as carpets, are allied to construction.

Recession has halted real-market price rises



a Average real-market value. **Sources:** International Trade Commission, industry, C&EN estimates

The market slump for phenol and vinyl acetate is bad enough that plant capacity has been cut. Capacity has become marginal for various reasons. For example, in the case of Union Carbide's shut-down phenol plant in Puerto Rico, feedstock no longer is available from nearby Commonwealth Oil. One industry source points out that if phenol's selling price were a lot higher, Carbide might bring in raw material cumene from the U.S. and continue running the Puerto Rican plant. But phenol has been just barely profitable in recent years, hardly justifying the effort.

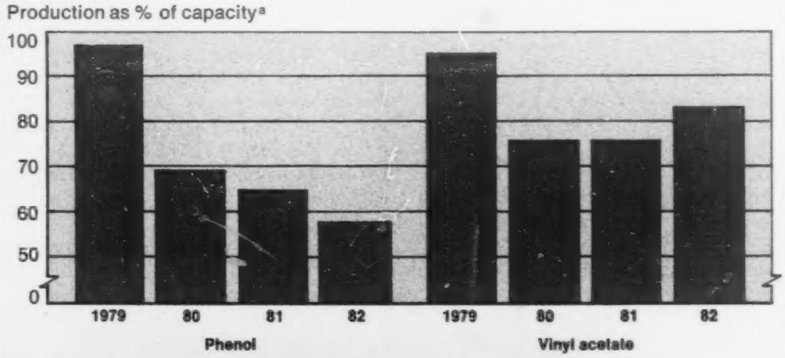
Similarly, Borden's acetylene-based vinyl acetate plant at Geismar, La., now shut down, probably was just barely profitable, especially in view of competition from newer technology.

For vinyl acetate, the shakeout in production capacity could be over, at least for a while. At the moment, four producers share the 2.3 billion lb of total capacity. All plants are large-scale, with none less than 400 million lb per year. Each is based on low-cost ethylene feedstock and uses up-to-date technology.

Phenol capacity, however, could drop even more and soon unless something unusual happens to boost demand. Several units have capacities of less than 100 million lb a year. These are operable, but not necessarily operating. Some of these units might be shut down if phenol demand stays at its current level of just over 2 billion lb a year. In essence, a second capacity drop of 400 million lb per year could occur. Even then, there would be little effect on profitability.

For the immediate market outlook in phenol and vinyl acetate, see the following pages.

Capacity use plummets for phenol, rises for vinyl acetate



a First-quarter nameplate capacity. **Sources:** International Trade Commission, industry, C&EN estimates

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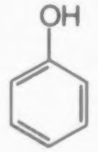
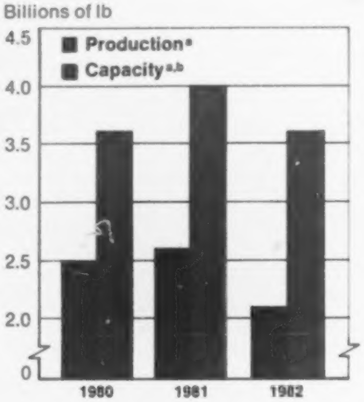
Key Chemicals

Phenol



- ***Production way off***
- ***Capacity cut***
- ***Prices discounted***

PRODUCTION/CAPACITY



a Synthetic only. b First quarter.

HOW MADE

Mainly peroxidation of cumene (isopropyl benzene) and cleavage to acetone and phenol

MAJOR DERIVATIVES (U.S.)

Resins (mostly with formaldehyde as comonomer) 40%, bisphenol A 20%, caprolactam 15%

MAJOR END USES (U.S.)

Adhesives 60%, plastics 20%, fibers 10%

FOREIGN TRADE

Exports—falling to 200 million lb in 1982, imports—negligible

PRICES

List prices 32.5 to 36 cents a lb

COMMERCIAL VALUE

$650 million for production, 1982

Phenol seems to be one of the ultimate commodity chemicals, a product that treats the ups and downs of the business cycle more like a roller coaster. Right now, phenol is screaming downhill. Output may be down 20% this year, prices are discounted more than 10% from list levels, exports are falling, and plants are shutting down.

Tracking the demand for plywood, phenol's largest end use as a binder, once gave joy to phenol producers, but not any more. With housing starts bumping along at low levels and fix-it work on older houses also down, plywood's plight now brings scowls to phenol producers' faces. The depression in housing means the same thing for phenol.

With the year half over, producers doubt that phenol production will top 2.1 billion lb in 1982, off as much as 20% from 2.6 billion lb in 1981. Even to reach 2.1 billion lb, phenol will need a pickup in the second half. For the first four months, annualized production was close to 2.0 billion lb, based on preliminary data from the International Trade Commission.

The path from phenol production to housing goes through a chain of phenol-formaldehyde resins to adhesives for plywood and for other competing board substitutes. More than 40% of phenol goes into these resins, and about 40% of the resins goes into plywood or particle board.

Besides board, an important use of the resins is as binders in glass-fiber insulation, various kinds of laminates, and other products used in home construction. These same materials also are used in commercial construction, which is declining in many areas. Clearly, construction of one kind or another determines how well phenol will do in any year.

Since construction has a history of sharp cycles, phenol producers are no strangers to stormy weather. Back in 1979, phenol production reached a record of almost 3 billion lb. But it dropped to 2.5 billion lb in 1980, edged up in 1981, and then nosedived in 1982. In the previous recession in 1975, phenol also was jolted for a 500 million lb decline.

Currently, one of the major cost problems facing producers is inefficient plant operating rates. For 1982, the average rate will be less than 60% of nameplate capacity. In 1981, the rate was about 65%.

The operating rate still is dropping despite a decline in capacity from a fire at Allied's phenol unit at Frankford, Pa., and permanent shutdown of Union Carbide's unit in Puerto Rico. These reductions have been offset partially by expansions now fully completed at General Electric and Georgia-Pacific. Industry sources estimate a net decline for 1982 of about 400 million lb.

With demand for phenol down so much, Allied has little incentive to rush repairs. Other producers have extended scheduled maintenance shutdowns of plants this spring in an effort to reduce inventories. Even so, phenol supplies are more than adequate for all markets, resulting in continued discounting of selling prices.

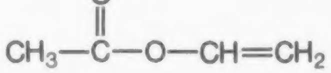
Except for minor uses, no phenol outlet will grow in 1982. Just as in housing, the recession and high interest rates hurt demand in autos and most other consumer durables. Phenol is hit hard in these uses in many ways. For example, when production of autos, farm machinery, and most other large-sized equipment declines, demand for castings drops and, with it, demand for phenolic resins for binders in molds and cores. With fewer castings to finish, demand for phenol resins used in making grinding wheels and other abrasive products drops at about the same rate.

Chemical derivatives of phenol also have stumbled in their growth as a result of the recession. Bisphenol A, 90% of which is further reacted to make epoxy and polycarbonate resins, has felt the effects. Caprolactam, nearly all of which becomes nylon 6 fibers and resins, has been hit by the housing decline because a big part of nylon 6 goes to carpets. Considerable growth in demand for phenol to make aniline had been expected this year, but after starting up its new unit to make aniline from phenol, USS Chemicals shut the plant down because of low demand.

An across-the-board demand slump, then, is phenol's lot in 1982. Until the big-ticket durables revive with the economy, phenol producers will have to try their best just to break even.

Key Chemicals

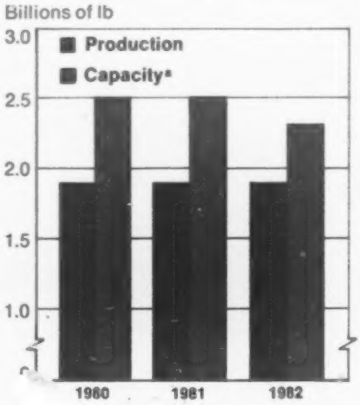
Vinyl acetate



$CH_3-\overset{\overset{\displaystyle O}{\|}}{C}-O-CH=CH_2$

- ***Demand holding***
- ***Capacity down a bit***
- ***Prices discounted***

PRODUCTION/CAPACITY



a First quarter.

HOW MADE

Vapor-phase reaction of ethylene, acetic acid, and oxygen

MAJOR DERIVATIVES (U.S.)

Polymers 55%, polyvinyl alcohol 20%, copolymers 15%

MAJOR END USES (U.S.)

Adhesives 35%, paints 25%, paper and textile coatings 20%

FOREIGN TRADE

Exports—holding at about 600 million lb in 1982, imports—negligible

PRICES

List prices 37.5 cents a lb; discounting relatively small

COMMERCIAL VALUE

$700 million for production, 1982

U.S. vinyl acetate producers may find themselves in a select circle this year—the fortunate makers of organic chemicals whose production isn't declining. There won't be many such chemicals. At that, vinyl acetate may just skin through by matching 1981.

If vinyl acetate succeeds with production of about 1.9 billion lb, the product will have extended a plateau for a third year since the 1979 peak of just under 2.0 billion lb. Ordinarily, three years of no growth would mean trouble for a chemical. But these days, with the recession in housing and automobiles taking such a toll, matching past years' production is an achievement.

An even greater achievement this recession year would be an increase in plant operating rates. And vinyl acetate probably will do it, but for a special reason—shutdown of old capacity. Borden Chemical's vinyl acetate unit at Geismar, La., based on acetylene, has not operated for some time, but it still has been included in C&EN's reckoning of capacity. With final shutdown of that unit, however, total capacity has declined on a nameplate basis to a bit more than 2.3 billion lb a year. This puts the average use rate for 1982 at 83%, up from 76% in 1981.

A bit more capacity, 100 million lb per year, will be completed this year by Union Carbide at Texas City, Tex. This expansion, the final phase of a two-part program, likely will be completed during the third quarter and be available for a small amount of production in 1982.

Vinyl acetate's enviably high plant operating rate admittedly might seem on shaky ground. So far this year, demand has been good enough that producers came within 20 million lb of 1981 production for the first five months, according to the International Trade Commission's preliminary data. However, vinyl acetate will have to survive a lot of pressured markets for the rest of 1982, including its important export business.

Exports in 1981 exceeded 600 million lb, just under 1980's level. Some industry sources expect exports in 1982 to drop at least 10% and possibly 20%. However, so far, exports have run at an all-time high of more than 650 million lb annualized from estimates for the first five months.

Perhaps later this year and in 1983, exports will decline as new capacity comes on stream overseas and antidumping duties bite. However, capacity often gets delayed in startup and frequently fails to produce in quantity or quality for some time afterward. Such difficulties would help U.S. exports, causing unexpected surges in monthly exports and upsetting forecasts.

Similarly, demand for polymers made using vinyl acetate as monomer or comonomer has been holding up better than expected. On the surface, the decline in housing should have hurt polyvinyl acetate because one of its major end uses is in paint. But several small factors combine to make paint use hold up. One example is capture of small amounts of the market from acrylics for cost reasons.

Adhesives uses, heavily dependent on construction, also apparently are holding up. Other adhesives-containing polymers of vinyl acetate go into a wide variety of packaging and auxiliaries such as labels.

Competition exists for most of the adhesive uses. However, for reasons of cost, convenience, and tradition, vinyl acetate-based adhesives are managing to hold on, expand slowly, and sometimes move into new applications.

Other polymer uses of vinyl acetate come through polyvinyl alcohol, made by hydrolyzing polyvinyl acetate. The largest use of polyvinyl alcohol is in textile sizes, particularly for those used on polyester-cotton blends. Again, cost-performance gives the nod to polyvinyl alcohol sizes over competing starch or acrylic acid-based sizes.

Remaining markets for vinyl acetate are a bit smaller and are suffering in some cases. Polyvinyl butyral goes mainly to lamination of glass, hurt on one hand by the decline in auto production but helped on the other by growth in architectural use of glass. Copolymers with ethylene and vinyl chloride go into a host of adhesive, coating, film, construction, and other uses. None of these have demand swings large enough to have a major impact on vinyl acetate consumption.

The net result of vinyl acetate's far-flung use pattern is just the opposite of phenol's much narrower spectrum—stability in a turbulent year.

NOTE

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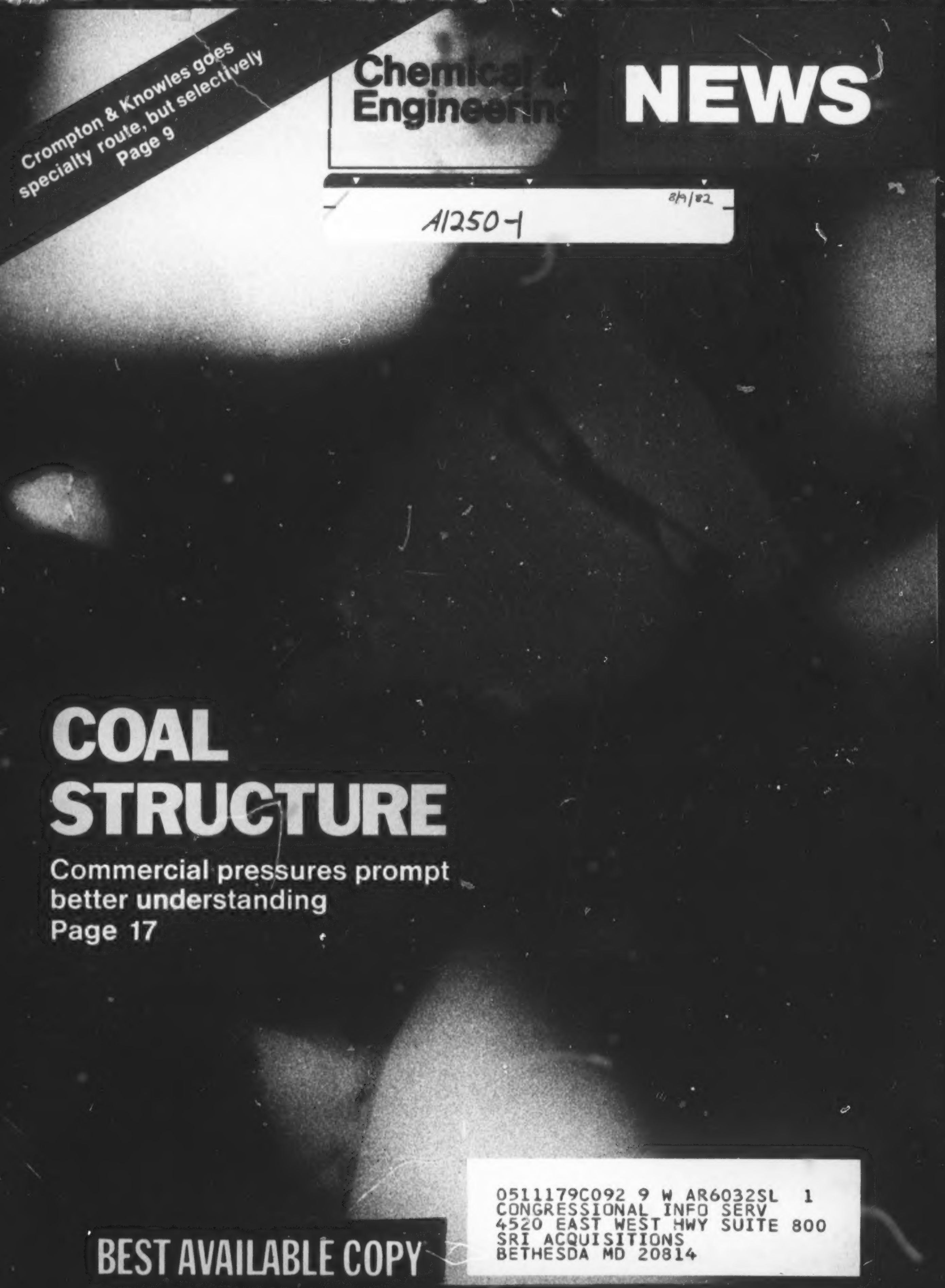

Crompton & Knowles goes specialty route, but selectively
Page 9

COAL STRUCTURE

Commercial pressures prompt better understanding
Page 17

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Cover: Fluorescing resinite particles in a resinite concentrate from Hiawatha coal seam in Utah. Photo courtesy of Southern Illinois University

2 Letters
3 Editor's Page

Concentrates

7 Business
13 Government
16 Science/Technology

The Departments

30 ACS Comment
36 Meetings
44 Newscripts

News of the Week

- ***EPA backs off*** *from proposal to relax lead-in-gasoline regulations in face of opposition from many quarters.* ***Page 4***
- ***W. R. Grace & Co. will give*** *up to $8.5 million to MIT for cooperative biotechnology research over next five years.* ***Page 5***
- ***Expanded metallurgy and ceramics*** *research building at GE lab features computer-regulated equipment.* ***Page 5***
- ***Council for Chemical Research*** *distributes more than $500,000 to university chemistry and engineering departments.* ***Page 5***
- ***Projected cost savings*** *in Administration's plan to dismantle the Department of Energy challenged by GAO.* ***Page 6***
- ***A simple system*** *for converting ethanol and water mixtures into gasoline developed by Purdue University scientists.* ***Page 6***

Business

- ***Crompton & Knowles fulfills restructuring program*** *by selling textile-machinery business; looks to acquire firms with good potential for growth.* ***Page 9***

International

- ***Australia plans to expand*** *petrochemicals and plastics industries during the decade, including tripling of ethylene capacity, by building world-scale plants.* ***Page 11***
- ***Synthetic lubricants market*** *in Europe projected to more than double by 1990, especially for down-sized diesel-engine vehicles, consultants report.* ***Page 12***

Government

- ***EPA-proposed changes to Clean Water Act*** *include extension of deadlines for complying with toxic pollutant standards, changes in treatment plant rules.* ***Page 14***

Science

- ***Coal****—our legacy from the flora and fauna of earlier ages and hope for replacing dwindling oil and gas supplies—is the object of renewed research interest.* ***Page 17***
- ***General methods for making monodispersed metal oxide colloids,*** *developed by Clarkson College chemists lead to uses in studying corrosion, catalysis, pigments.* ***Page 26***

Education

- ***Fairleigh Dickinson's 9-7-3 cooperative education program*** *gives students more time in off-campus work periods, allows industry to evaluate potential employees.* ***Page 29***

ACS News

- ***ACS Council*** *will consider three petitions at Kansas City meeting; will experiment with earlier meeting day.* ***Page 30***

Australia plans growth in petrochemicals

Expansion of petrochemical and plastics industries in the 1980s assumes increased domestic demand as well as adequate feedstock supplies

Australia plans considerable expansion of its petrochemical and plastics industries in the 1980s. Indeed, development projects under discussion would more than triple ethylene capacity, to about 900,000 metric tons a year, by 1990.

A look at the prospects and possible developments over the rest of this decade—particularly for production of olefins and synthetic resins—is given by a recent report by the Chemicals & Plastics Industries Advisory Council (CPIAC) of Australia's Department of Industry & Commerce. The report includes data prepared by the Australian Chemical Industry Council.

The petrochemical industry in Australia expanded rapidly in the 1970s, growing faster in production, productivity, and investment than manufacturing industry in general. This followed rapid growth in the 1950s and 1960s, based originally on wartime, government-built plants. Tariff barriers have protected domestic producers. Tariff rates for polyolefins still are generally higher than in other countries.

The industry now is approaching maturity, and the current development phase calls for construction of ethylene and other plants of almost world-scale size. (In the past, it often has been considered more economical to build smaller local plants because of very high freight costs, sacrificing economies of scale.)

Sales in the synthetic resins and synthetic rubber industry amounted to about $808 million for July 1979 to June 1980, the most recent year for which figures are available. Nearly 5100 are employed in the industry. Most of the production is sold domestically. (Exports of major resins totaled 5% of domestic consumption in 1979–80.)

The two major petrochemical complexes are located at Altona, Victoria, and at Botany, New South Wales, near the main markets in Sydney and Melbourne. The main feedstocks for the Altona complex are ethane from Bass Strait and gas oil from a local refinery. The Botany complex's major feedstock is naphtha.

Between 1965 and 1974, Australia's domestic ethylene market grew more than 13% a year. The rate of growth has slowed since—a natural consequence of the industry's maturing. Synthetic resins have to some extent already replaced other materials.

However, consumption of ethylene-based polymers still is projected to grow 7% a year in 1980–85 and 6.5% a year in 1985–90, almost doubling from 354,000 metric tons a year in 1980 to 682,000 in 1990. These are considerably higher growth rates than anticipated for consumption of these resins in the U.S. and Western Europe. Australian per capita consumption of all resins was only 40 kg in 1979, compared to 105 kg in West Germany and 77 kg in the U.S.

Australia's demand for ethylene presently exceeds production capacity, and ethylene is being imported into Botany until current plant expansions are completed. Butadiene capacity also is inadequate to demand (now about 35,000 metric tons a year). On the other hand, propylene capacity exceeds domestic demand. The market for polypropylene is at an earlier stage of development than for polyethylene, and polypropylene consumption is projected to grow 9.6% a year in 1980–85 and 7.3% a year in 1985–90, rising from 62,000 metric tons in 1980 to 139,000 in 1990.

The expected increase in demand for ethylene raises two questions, notes the CPIAC report: Will local plants have the capacity to handle that volume? And from where will feedstocks come?

Demand for ethylene is expected to grow to about 603,000 metric tons a year by 1990. Currently, about 120,000 metric tons a year is produced from Bass Strait ethane, 100,000 from refinery and imported naphtha (40% imported from Bahrain), and 50,000 from refinery gas and gas oil. Planned expansion in the Botany and Altona complexes at a cost of some $740 million—to be completed by 1985—will increase ethylene output about 350,000 metric tons a year.

Moreover, under consideration by several interests, including Japanese firms, is an ethylene plant development in South Australia that may cost as much as $1 billion or more. That plant also will produce chlorine, caustic soda, and dichloroethylene. And new petrochemical developments have been discussed for

Consumption of ethylene polymers will nearly double by 1990 . . .

Thousands of metric tons	1980[a]	1985	1990	Annual growth 1980–85	 1985–90
Polyvinyl chloride	137	189	251	6.7%	5.8%
Polyethylene, low density	120	167	232	6.8	6.8
Polyethylene, high density	61	93	138	8.7	8.2
Polystyrene	36	48	61	5.9	4.9
TOTAL	**354**	**497**	**682**	**7.0%**	**6.5%**

. . . as will Australian market demand for ethylene

Thousands of metric tons of ethylene equivalent	1980	1985	1990
Polyvinyl chloride	68	92	122
Polyethylene, low density	125	175	240
Polyethylene, high density	66	98	145
Polystyrene	12	15	20
Other ethylene derivatives	45	60	76
TOTAL	**316**	**440**	**603**

[a] Annual average over 1978–80 taken as base to eliminate unrepresentative figures in 1979–80 caused by abnormal market forces. **Source:** Australian Chemical Industry Council

Western Australia by a consortium of leading Australian companies (based on feedstocks from the North West Shelf) and for northern Queensland by Occidental Petroleum.

Australia is relatively well endowed with feedstock for petrochemical expansion until at least 1990, based on continued development of its oil and natural gas fields—especially the latter, the CPIAC report says. If all the development projects were to be built, total ethylene capacity would rise to about 900,000 metric tons a year. Feedstocks used at present might provide about 500,000 metric tons of this total (350,000 from ethane, 100,000 from naphtha, and 50,000 from other refinery products). The remaining 400,000 metric tons of ethylene could be produced by use of liquefied petroleum gas (LPG), most of which is exported.

However, Australia's government is giving high priority to plans for use of LPG as a motor vehicle fuel. Thus, the report concludes, to meet a possible shortfall in feedstocks in the late 1980s or early 1990s, a change in government policy on LPG use should be considered. ◻

Synlubes market set for growth in Europe

Traffic lights have flashed bright green for synthetic lubricants in the U.S. and abroad ever since Mobil started the market going in the mid-1970s. This product group has been touted as one of the fastest growth areas in the chemical industry—to the point of squeezing available raw materials and taxing companies' investment schedules.

Synlubes also support a flourishing market for consultants, who regularly map the future for this chemical group. It happens that synlubes have several quite different starting materials and end uses.

The latest study on synlubes treats the coming decade for the market in Europe. Growth in the European Economic Community figures to be good, though synlubes will remain tucked in a very small niche of the overall lubricant business, concludes consultants Frost & Sullivan of New York City and London. It won't all be smooth sailing either, as headwinds develop from poor economies and lower-cost substitutes.

Overall, Frost & Sullivan expects EEC volume in synlubes to more than double from 81,000 tons in 1980 to 197,000 tons in 1990. In constant 1980 dollars, market value would jump from $211 million to $495 million. More than 70% of 1980 sales were in just three countries—West Germany, France, and the U.K.

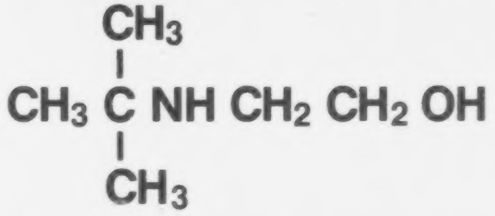
The big hope for the new lubricants is in the vast consumer automobile market. Frost & Sullivan puts sales growth in this market at 13 to 14% per year, pushing autos' share of the total synlubes market from about 26% in 1980 to nearly 39% in 1990. "The practice in recent years of European auto manufacturers to down-size car engines has led to starting problems in cold climates, and the high-revving engines of these small cars cause petroleum-based lubricants to break down after relatively low mileage. The starting problem has been particularly noticeable in diesel engine vehicles, particularly in the harsh winter of 1981–82. The growth of the diesel car market, estimated to average nearly 12% per year in EEC through the 1980s, is expected to increase demand for synthetics."

Synlubes' big market share jump in autos will come somewhat at the expense of market share in industrial uses such as hydraulic fluids, fire-resistant fluids, metalworking lubricants, and industrial gear lubricants. The industrial segment's cut of total sales is forecast to slip from 54% in 1980 to 48% in 1990. Similar below-average growth in aviation uses, just 5% per year, will bring down market share here from 20% to 13% during the 1980s.

But even with all this growth, synthetics scarcely will nick the overall lubricants trade. Synlubes accounted for less than 2% of the total EEC lubricants market in 1980, the study finds, despite average annual growth at 10% in the 1970s.

A possible brake to future synlubes growth could come in lower-cost competing products, the report warns. The current recession is causing companies to cut corners, and many potential end users of synthetics could turn to substantially cheaper mineral oil-based lubricants. Perhaps even more threatening, the report notes, is a recent development by some oil companies of "hydro-crack oils," specifically designed for the auto market featuring many of the synthetics' properties at a lower price. ◻

Try tertiary-Butylaminoethanol.



$$CH_3C(CH_3)_2NHCH_2CH_2OH$$

Another new alkyl alkanol amine from Pennwalt.

Pennwalt now has tertiary-butylaminoethanol available in commercial quantities. This new amine structure has several interesting known applications and potential for several other manufacturing processes. As a source of both a hydroxyl group and a specific amine radical, it is potentially useful in the synthesis of a number of pharmaceuticals. It is used to make acrylate esters, and cathodic electroplated materials. As an additive for polyester and alkyd resins it improves compatibility with other resins and increases solubility in aliphatic hydrocarbons.

For technical data and a sample, contact Market Development Department, Organic Chemicals Division, Pennwalt Corporation, Three Parkway, Philadelphia, PA 19102. (215) 587-7141.

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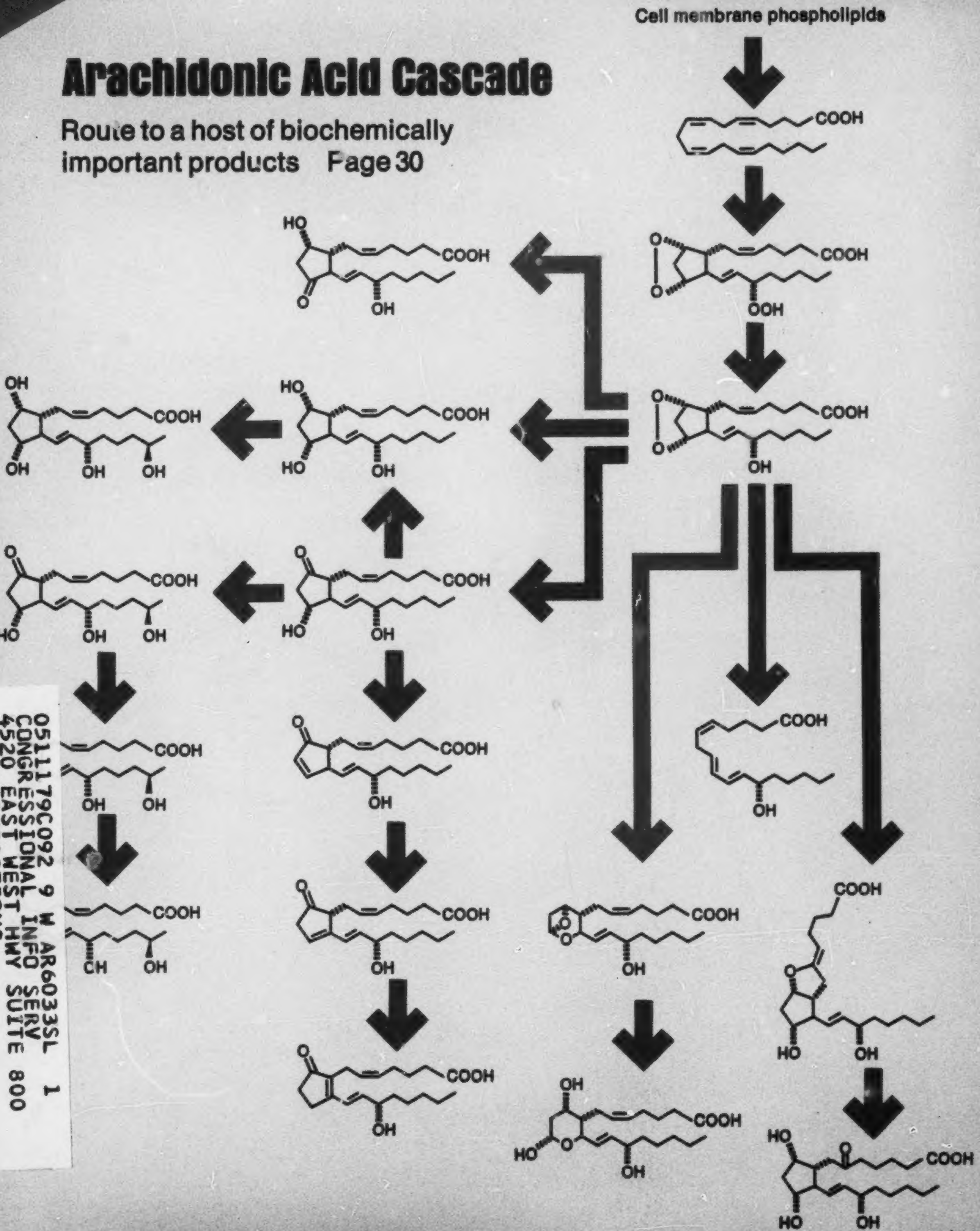
Chemical & Engineering NEWS

Earnings debacle continues for U.S. chemical industry Page 10

Arachidonic Acid Cascade

Route to a host of biochemically important products Page 30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Chemical & Engineering NEWS

4 Letters
5 Editor's Page

Concentrates
9 Business
19 Government
24 Science/Technology

The Departments
45 ACS News
56 Newscripts

News of the Week

- ***Gulf Oil's decision*** *not to take it over leaves Cities Service vulnerable to other, low-cost bids; company may liquidate if another buyer cannot be found.* ***Page 6***
- ***Chemical industry lost*** *a number of changes it had hoped for in House-passed pesticides control laws.* ***Page 7***
- ***Patent office rejects*** *Stanford University application for products patent based on genetic engineering techniques.* ***Page 7***
- ***Executive order on classifying information*** *for national security reasons criticized by House committee.* ***Page 7***
- ***George C. Pimental*** *withdraws as candidate for 1983 ACS president-elect; F. Albert Cotton and petition candidate Warren D. Niederhauser will vie for post.* ***Page 8***
- ***Ceramics research center*** *at Rutgers University, set up by NSF grant, will receive support from six industrial firms.* ***Page 8***

Business

- ***Recession continues to batter chemical company earnings;*** *first-half results indicate one of the worst years for the industry if demand doesn't pick up.* ***Page 10***

International

- ***Major Canadian chemical companies*** *continue to experience deepest economic slump since the 1930s; only one company has shown profits this year.* ***Page 18***

Government

- ***Pollution bills, other legislation*** *slow to be approved by Congress; Clean Air and Clean Water acts still in rewrite stage.* ***Page 20***
- ***New bills being introduced in Congress*** *to try to halt trend toward national scientific illiteracy.* ***Page 22***

Science

- ***Synthesis of dodecahedrane*** *opens doors to studies of the fundamental nature of all organic compounds.* ***Page 25***
- ***Fredricamycin A*** *shows promise as antitumor drug and antibiotic.* ***Page 27***

Technology

- ***Stauffer's Pro-Drone controls fire ant*** *infestation by creating an excess of idle insects, shortage of worker ants.* ***Page 27***

Education

- ***Master's degree program*** *in chemical engineering set up by Columbia University and Exxon Research & Engineering.* ***Page 29***

Special Report

The arachidonic acid cascade *includes prostaglandins, thromboxanes, and many other biochemically important products of enzymic oxidation of the acid.* ***Page 30***

Chemical company earnings continue plunge

If the first half is any indication, 1982 will end up with the worst profit drop and the lowest profit margin for the industry in years

William J. Storck, C&EN, New York, and William F. Fallwell, C&EN, Washington

In a few months, U.S. chemical producers will look back on 1982 with a mixture of relief that it is over and hope that it never happens again.

Projected from what has happened so far, negative superlatives looming for 1982 include the industry's worst profit drop and lowest profit margin in recent decades. In a nutshell, C&EN's midyear survey of the 40 leading basic chemical companies projects a profit drop of at least 20% for the year on a sales drop of at least 3%. Profit margin on sales will be the lowest ever at less than 5%.

For the second quarter, profits of these chemical companies fell 36% from a year ago as sales slipped 8%. The average second-quarter profit margin was 4.4%. These results are particularly bad, since the second quarter is traditionally the industry's strongest of the year.

The industry has come to this pass because the current recession has lasted too long—running off and on for three years since 1979. The industry finds itself with tremendous price discounting and record low plant use rates when demand is still weakening. This is in sharp contrast to the 1975 recession, when the chemical industry began to recover before prices slid. The softening of prices in mid-decade did not hit until 1976. By that time, the recession was over, and demand was starting to pick up.

This time around, there is nothing like renewed markets to buffer prices, which have been smashed 30 to 40% for many basic chemicals and polymers. As a result, chemical sales will decline 3 to 7% in 1982, and earnings will drop 20 to 30% from last year. Profit margin on sales will touch bottom at 4.0 to 4.6%. Even during the 1975 recession, profit margin for the 40 firms on the C&EN list of chemical companies stayed high at 8.6%, falling to 6.2% in 1976.

Some economists, such as Charles B. Reeder of Du Pont, still are predicting the beginning of a recovery

Chemical industry leaders for second-quarter 1982 . . .

Sales

Rank		$ Millions	Rank 1981
1	Dow Chemical	$2728.0	1
2	Union Carbide	2290.4	2
3	W. R. Grace	1630.2	4
4	Monsanto	1623.4	3
5	Allied	1595.0	5
6	FMC	904.8	9
7	American Cyanamid	901.1	7
8	PPG Industries	882.1	8
9	B. F. Goodrich	793.5	10
10	Celanese	778.0	6

Earnings[a]

	$ Millions	Rank 1981
Union Carbide	$118.2	2
Monsanto	86.2	5
Allied	82.0	3
Dow Chemical	77.0	1
W. R. Grace	76.9	4
PPG Industries	45.7	6
FMC	39.0	8
American Cyanamid	31.4	7
Rohm & Haas	28.0	13
Ethyl	27.9	17

Profitability

	Earnings as % of sales	Rank 1981
International Flavors	16.0%	3
Nalco Chemical	9.9	5
Petrolite	9.7	8
Freeport-McMoRan	8.8	1
Great Lakes Chemical	8.0	4
Philip A. Hunt	6.7	14
Air Products	6.4	9
Liquid Air	6.4	11
Chemed	6.2	6
Lubrizol	6.2	7

. . . and for first-half 1982

Sales

Rank		$ Millions	Rank 1981
1	Dow Chemical	$5509.0	1
2	Union Carbide	4611.5	2
3	Monsanto	3351.1	3
4	Allied	3209.0	5
5	W. R. Grace	3093.4	4
6	FMC	1749.4	9
7	American Cyanamid	1746.6	7
8	Celanese	1638.0	6
9	PPG Industries	1600.0	8
10	B. F. Goodrich	1500.0	10

Earnings[a]

	$ Millions	Rank 1981
Monsanto	$233.7	3
Union Carbide	209.0	2
Dow Chemical	174.0	1
W. R. Grace	156.0	4
Allied	145.0	5
Stauffer Chemical	99.3	7
FMC	69.5	10
PPG Industries	62.2	6
American Cyanamid	59.8	8
Air Products	53.5	16

Profitability

	Earnings as % of sales	Rank 1981
International Flavors	15.6%	2
Freeport-McMoRan	11.3	1
Stauffer Chemical	10.6	5
Petrolite	10.0	8
Nalco Chemical	9.8	4
Great Lakes Chemical	8.6	3
Chemed	7.4	9
Liquid Air	7.0	12
Monsanto	7.0	14
Air Products	6.9	11
Lubrizol	6.9	6

a After taxes. Note: For 40 chemical companies on page 12.

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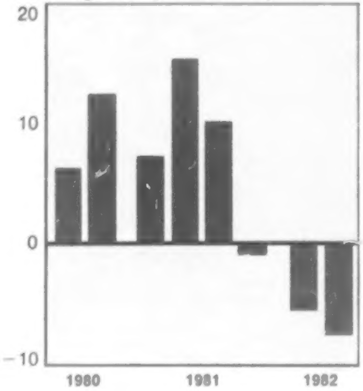
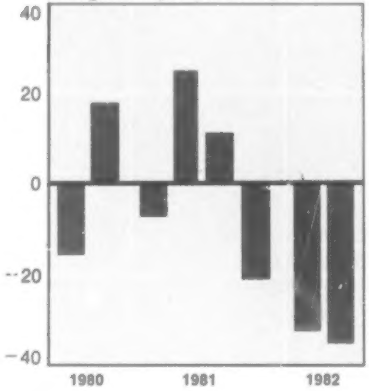
Chemical industry 1982 second-quarter results

- **Sales fell 8%**
- **Earnings plunged 36%**
- **Profit margin was 4.4%**
- **Production declined 11%**
- **Prices rose 2.3%**



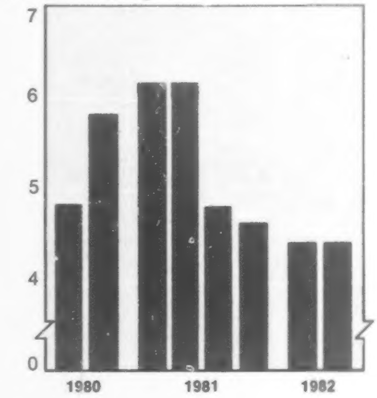
Sales

% change from year-earlier quarter



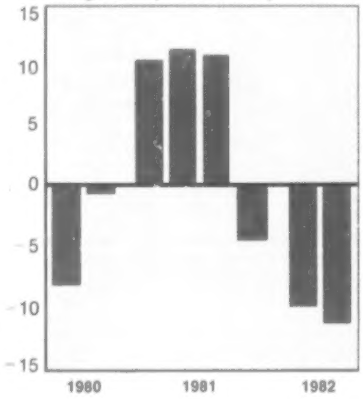
Earnings

% change from year-earlier quarter



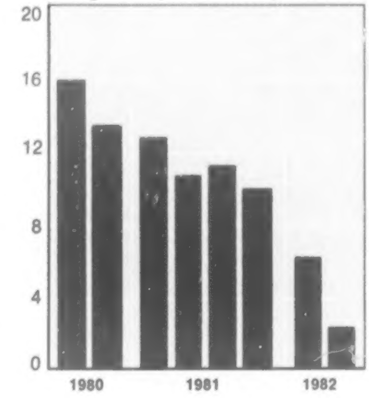
Profit margins

After-tax earnings as % of sales



Production

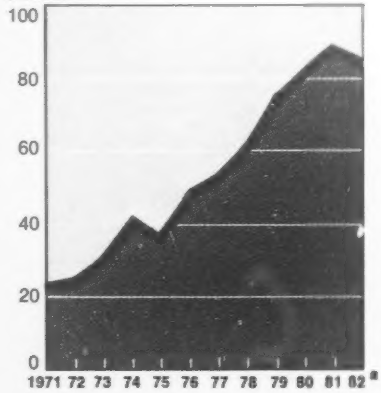
% change from year-earlier quarter



Prices

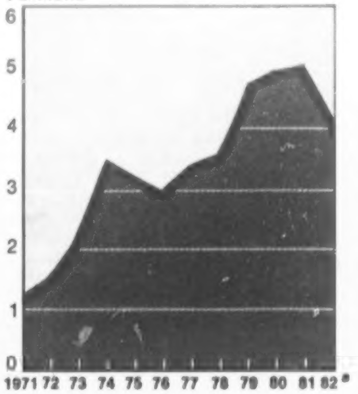
% change from year-earlier quarter

Sales in 1982 will fall about 3% and earnings will drop more than 20%, driving chemical profitability down to about 4.6%



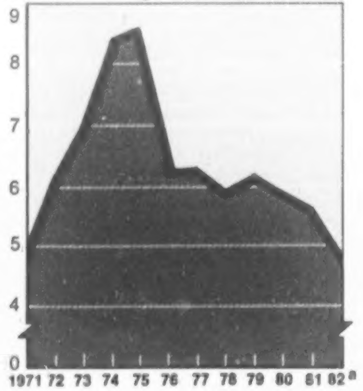
Annual sales

$ Billions



Annual earnings

$ Billions



Annual profit margins

After-tax earnings as % of sales

a C&EN estimates. **Note:** All sales, earnings, and profit margin data are based on the combined performance of the 40 largest chemical companies listed on page 12.

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Earnings for 40 largest chemical companies in first half down 36% from 1981

	SECOND-QUARTER 1982						FIRST-HALF 1982			
	Sales	Earnings	Change from 1981		Profit margin[a]		Sales	Earnings	Change from 1981	
	($ millions)		Sales	Earnings	1982	1981	($ millions)		Sales	Earnings
Dow Chemical[d]	$ 2,728.0	$ 77.0	−11%	−54%	2.8%	5.5%	$ 5,509.0	$174.0	−8%	−50%
Union Carbide	2,299.4	118.2	−14	−35	5.1	6.8	4,611.5	209.0	−13	−40
W. R. Grace[e]	1,630.2	76.9	−4	−23	4.7	5.9	3,093.4	156.0	−3	−15
Monsanto	1,623.4	86.2	−13	−8	5.3	5.1	3,355.1	233.7	−11	−13
Allied	1,595.0	82.0	−1	−6	5.1	5.5	3,209.0	145.0	−1	−15
FMC	904.8	39.0	8	−13	4.3	5.4	1,749.4	69.5	6	−23
American Cyanamid[f]	901.1	31.4	0	−35	3.5	5.0	1,746.6	59.8	−2	−36
PPG Industries[g]	882.1	45.7	−1	−29	5.2	7.2	1,600.0	62.2	−6	−48
B. F. Goodrich[h]	793.5	15.0	−4	−43	1.9	3.2	1,500.0	−3.4	−6	def
Celanese	778.0	18.0	−21	−55	2.3	4.0	1,638.0	38.0	−14	−50
Hercules	651.0	22.3	−9	−46	3.4	5.8	1,291.0	44.2	−6	−48
Williams Cos.	558.0	19.4	−3	−49	3.5	6.6	952.0	25.3	−11	−72
Rohm & Haas[i]	528.0	28.0	−3	−17	5.3	6.2	1,003.3	44.0	−2	−28
Olin	474.2	23.4	−13	−29	4.9	6.0	973.9	45.4	−9	−26
National Distillers[j]	464.9	22.3	−11	−37	4.8	6.8	929.3	39.2	−10	−44
Ethyl[k]	417.6	27.9	−8	14	6.7	5.4	820.3	45.1	−7	2
International Minerals[l]	400.7	4.7	−15	−84	1.2	6.3	819.8	28.2	−19	−63
Air Products[m]	380.7	24.2	−2	−14	6.4	7.2	779.7	53.5	−3	−18
Witco Chemical	335.9	8.9	0	−14	2.7	3.1	669.9	12.8	2	−21
Stauffer Chemical	305.6	17.2	−19	−25	5.6	6.1	935.9	99.3	−7	−11
Akzona	254.8	−4.3	−19	def	def	1.8	545.4	−7.0	−12	def
Pennwalt	253.7	11.0	−9	−30	4.3	5.6	500.4	17.2	−9	−33
Lubrizol	220.7	13.6	−8	−48	6.2	10.8	422.5	29.2	−9	−42
Reichhold Chemicals	218.8	3.8	−14	−46	1.7	2.8	432.7	7.1	−12	−39
Thiokol	210.7	9.5	19	8	4.5	5.0	413.6	18.5	18	9
Freeport-McMoRan	175.0	15.4	−16	−64	8.8	20.5	369.9	49.1	−15	−54
Nalco Chemical	166.1	16.4	1	−16	9.9	11.9	324.9	31.8	1	−18
GAF[i]	163.4	8.9	−6	107	5.4	2.5	302.9	5.1	−14	−31
International Flavors	123.5	19.8	3	−8	16.0	17.9	242.1	37.8	−1	−10
Liquid Air	120.3	7.8	10	3	6.4	6.9	223.8	15.6	2	−8
H. B. Fuller[n]	83.0	3.0	−2	−21	3.6	4.5	155.6	4.0	−4	−38
Petrolite	74.9	7.3	0	−3	9.7	10.0	157.3	15.8	8	9
Chemed	64.8	4.0	2	−30	6.2	10.9	124.7	9.2	2	−14
First Mississippi	62.1	3.5	−4	−72	5.6	19.4	113.8	4.7	−12	−64
Crompton & Knowles	55.9	1.3	−15	−46	2.3	3.6	110.0	2.1	−13	−50
Loctite	54.4	3.2	−3	10	5.9	4.7	109.2	6.5	−3	16
Stepan Chemical	52.4	1.4	−6	−25	2.7	3.3	106.5	2.4	1	−20
Essex Chemical	47.1	2.6	−10	4	5.5	4.8	84.8	3.4	−8	21
Great Lakes Chemical	40.1	3.2	16	−32	8.0	13.6	82.8	7.1	19	−29
Philip A. Hunt	29.7	2.0	4	8	6.7	6.6	59.8	4.0	9	38
Total 20 largest companies	**$18,652.1**	**$787.7**	**−7.9%**	**−35.6%**	**4.2%**	**6.0%**	**$37,186.9**	**$1580.8**	**−6.9%**	**−34.6%**
Total 20 other companies	**$2,471.4**	**$133.4**	**−4.6%**	**−34.7%**	**5.4%**	**7.9%**	**$4,882.7**	**$263.6**	**−5.5%**	**−31.3%**
Grand total	**$21,123.5**	**$921.1**	**−7.6%**	**−35.5%**	**4.4%**	**6.2%**	**$42,069.6**	**$1844.4**	**−6.8%**	**−34.1%**

a After-tax income as a percentage of sales. **b** Fully diluted before nonrecurring and extraordinary items. **c** As of July 30. **d** Excludes $120 million nonrecurring gain in second-quarter 1982, $57 million extraordinary credit in first-quarter 1982, and $20 million nonrecurring gain in second-quarter 1981. **e** Excludes $65.1 million nonrecurring gain in first-half 1982. **f** Excludes net nonrecurring charge of $3.4 million in second-quarter 1982, net gain of $3.4 million in second-quarter and first-half 1981, and net gain of $6.2 million in first-half 1982. **g** Excludes $7.2 million nonrecurring gain in first-half 1982. **h** Excludes nonrecurring gains of $4.4 million in second-quarter 1982 and $18 million in first-half 1981. **i** Excludes nonrecurring charge of $13.4 million

sometime in the second half of this year. They say that the economy already has hit bottom. Businessmen echo such hopes but have little hard evidence to back them up.

Other economists, however, are having none of this. For example, Irwin L. Kellner, senior vice president and chief economist for Manufacturers Hanover Trust, says that forecasters who see a strong upturn in the second half of the year are ignoring important negative signals given off by the economy. Although proponents of a second-half pickup in economic activity point to new growth that the Federal Reserve Board will allow in the monetary aggregates, Kellner says "they fail to take into account the fact that the demand for money continues to overwhelm the supply."

In terms of consumer spending, Kellner thinks that the 10% tax cut and the 7.5% rise in social security benefits are not only too small to boost spending, but are more than

FIRST-HALF 1982		12-MONTH RUNNING DATA						STOCK MARKET DATA[c]					
Profit margin[a]		Change from 1981		Profit margin[a]		Earnings per share[b]		Stock price			Price earnings ratio July 30	Annual indicated dividend	Dividend yield, % of price
									Recent 12 months				
1982	1981	Sales	Earnings	1982	1981	2nd qtr	Recent 12 months	July 30	High	Low			
3.2%	5.8%	−5%	−42%	3.5%	5.8%	$0.40	$2.36	$20¼	$31⅞	$19⅞	9	$1.80	8.9%
4.5	6.6	−9	−25	6.3	5.1	1.71	7.09	42⅝	57⅜	40⅛	6	3.40	8.0
5.0	5.8	−1	6	5.2	4.9	1.57	6.40	30¼	51	30¼	5	2.80	9.3
7.0	7.2	−6	1	5.2	4.9	2.39	8.75	63¾	80⅝	56⅝	7	4.00	6.3
4.5	5.4	9	−5	4.9	5.6	2.01	7.69	34½	54⅜	28¾	4	2.40	7.0
4.0	5.5	7	15	4.7	4.4	1.06	4.55	25⅜	31⅜	23⅛	8	1.60	6.3
3.4	5.2	1	0	4.9	5.0	0.65	3.69	28¾	31¾	24⅜	8	1.75	6.1
3.9	7.0	−1	−32	4.7	6.9	1.33	4.68	35⅝	47¾	29	8	2.36	6.6
def	2.2	−3	−13	1.9	2.1	0.70	2.29	16⅞	24½	16⅞	7	1.56	9.2
2.3	4.0	−4	−24	3.0	3.8	1.05	6.05	42¼	64⅜	41¾	7	4.00	9.5
3.4	6.1	1	−4	4.7	4.9	0.51	2.81	17¼	24½	16⅞	6	1.32	7.7
2.7	8.4	−11	−71	2.1	6.5	0.65	1.52	14⅛	34¾	14	9	1.20	8.5
4.4	6.0	1	−20	4.3	5.4	2.17	5.66	50	68¼	45½	9	2.80	5.6
4.7	5.7	−3	−11	4.0	4.4	0.99	3.25	16½	24½	16¼	5	1.20	7.3
4.2	6.7	−2	10	6.1	5.5	0.61	3.37	20¼	26⅛	18⅞	6	2.20	10.9
5.5	5.2	−2	4	5.1	5.4	1.34	4.55	22⅜	28¾	18⅛	5	1.50	6.7
3.4	7.6	−16	−40	5.7	8.0	0.18	3.58	24⅞	46¼	24⅝	7	2.60	10.5
6.9	8.1	1	−3	7.5	7.8	0.84	4.01	27	40¼	26	7	0.80	3.0
1.9	2.5	3	−1	2.7	2.8	0.63	3.80	21	31½	20⅝	6	1.80	8.6
10.6	11.0	−6	−3	8.3	8.1	0.43	3.15	18⅞	24¾	17	6	1.44	7.6
def	1.4	−2	def	def	0.5	−0.35	−0.23	15¾	16⅛	7⅞	—	0.20	1.3
3.4	4.7	−21	−21	3.4	3.4	1.06	3.16	23⅝	31½	23⅛	7	2.20	9.3
6.9	10.8	−9	−11	9.8	10.0	0.34	1.81	15	26¾	14¼	8	1.08	7.2
1.6	2.4	−4	−31	1.7	2.3	0.44	1.70	10⅞	15¾	10	6	0.48	4.4
4.5	4.9	9	26	4.9	4.3	0.82	3.30	39¼	46	26½	12	1.20	3.1
11.3	21.2	−2	−35	14.1	21.2	0.23	1.62	13⅞	37½	13⅛	9	0.60	4.3
9.8	12.1	5	−4	11.1	12.1	0.41	3.30	19⅝	27¾	18⅝	6	1.12	5.7
1.7	2.1	−12	def	def	1.4	0.50	−1.79	10¼	15¼	8⅝	—	0.20	2.0
15.6	17.3	1	−17	12.6	15.3	0.54	1.56	23	23⅝	17⅜	15	1.00	4.3
7.0	7.7	4	5	7.1	7.0	0.60	2.52	17¼	22½	16¼	7	1.60	9.3
2.6	4.0	6	−8	3.4	4.0	0.65	2.41	16¾	26½	14¼	7	0.52	3.1
10.0	9.9	12	6	9.4	9.9	0.61	2.44	26¼	37	24¾	11	1.00	3.8
7.4	8.8	7	22	9.4	8.2	0.47	1.51	23½	25⅛	21⅝	16	1.25	5.3
4.1	10.1	−8	−57	4.2	8.8	0.17	0.52	8⅛	22⅜	7¾	16	0.24	3.0
1.9	3.3	−7	−16	2.9	3.1	0.35	1.81	13	18⅛	12⅛	7	1.04	8.0
6.0	5.0	1	39	6.7	4.9	0.32	1.45	18⅜	26½	18⅛	13	0.56	3.0
2.3	2.8	10	21	2.8	2.6	0.39	1.60	10⅛	21⅜	10⅛	6	0.56	5.5
4.8	3.7	−4	0	4.8	4.6	0.90	2.72	17⅛	20¼	15⅞	6	0.80	4.7
8.6	14.4	21	−23	9.3	14.6	0.44	2.00	27½	48⅛	26⅜	14	0.52	1.9
6.7	5.3	8	def	4.1	def	0.35	1.14	10¾	11¼	8⅜	9	0.40	3.7
4.3%	**6.0%**	**−2.6%**	**−16.6%**	**4.6%**	**5.4%**								
5.4%	**7.4%**	**−2.7%**	**−21.0%**	**5.5%**	**6.7%**								
4.4%	**6.6%**	**−2.6%**	**−17.2%**	**4.7%**	**5.5%**								

in second-quarter 1981 and net nonrecurring charge of $9.0 million for first-half 1981. **j** Excludes net nonrecurring loss of $4.3 million in second-quarter 1982 and net nonrecurring gain of $7.2 million in first-half 1982. **k** Second-quarter 1982 includes results from First Colony Life Insurance from May 14. **l** Includes nonrecurring items. **m** Excludes $9.3 million nonrecurring charge in second-quarter 1982. **n** Excludes $0.9 million extraordinary gain in first-half 1982. **def** = deficit.

wiped out by increases in taxes, fees, and utility rates at the state and local levels.

"If the consumer doesn't come through and lift his/her outlays dramatically starting this quarter," Kellner says, "then business inventories may not be in as good shape as some think." The ratio of business inventories to shipments in June was a distressingly high 1.8, compared with 1.7 in June 1981. For chemicals and allied products the ratio is moderately high at about 1.4, the same as in June 1981.

Kellner adds that even if consumers do increase their spending somewhat over the coming months, they will be more likely to buy small-ticket items that won't contribute much to the economic recovery. Autos and houses, which are big chemical markets, still would languish.

The National Association of Purchasing Management, source of the first hard data on monthly manufacturing activity, also has weighed in

Both sales and earnings fall at chemical-producing petroleum companies

		SECOND-QUARTER 1982						FIRST-HALF 1982		
	% chemical sales	Sales ($ millions)	Earnings ($ millions)	Change from 1981 Sales	Change from 1981 Earnings	Profit margin[a] 1982	Profit margin[a] 1981	Sales ($ millions)	Earnings ($ millions)	Change from 1981 Sales
Exxon	7%	$25,262.0	$885.0	−8%	−52%	3.5%	6.6%	$52,371.0	$2125.0	−9%
Mobil	3	15,754.0	310.0	−5	−56	2.0	4.2	32,193.0	636.0	−4
Texaco	3	11,500.0	305.0	−22	−45	2.7	3.8	24,500.0	672.0	−19
Standard Oil of California	3	9,370.0	263.0	−15	−57	2.8	5.6	19,390.0	493.0	−16
Standard Oil (Ind.)	11	7,549.0	382.0	−7	−31	5.1	6.8	14,714.0	852.0	−8
Gulf Oil	8	7,426.0	210.0	3	−32	2.8	4.3	14,964.0	477.0	−1
Atlantic Richfield	10	6,808.9	409.8	−2	3	6.0	5.7	13,236.0	795.2	−6
Shell Oil	15	5,105.0	380.0	−8	−7	7.4	7.4	9,947.0	724.0	−9
Occidental Petroleum[b]	15	4,300.3	66.4	37	−52	1.5	4.5	8,512.0	128.5	31
Phillips Petroleum	15	4,030.0	139.9	−1	−39	3.5	5.6	7,843.0	328.7	−16
Sun Co.[b]	5	4,000.0	110.0	3	−33	2.8	4.2	8,000.0	234.0	1
Tenneco[b]	10	3,735.0	159.0	0	−22	4.3	5.4	7,549.0	287.0	0
Standard Oil (Ohio)	3	3,156.8	473.2	−2	−1	15.0	14.9	6,212.4	927.9	−3
Getty Oil	2	3,078.3	151.5	−4	−26	4.9	6.4	6,202.9	315.4	−5
Union Oil[b]	11	2,909.7	197.6	4	8	6.8	6.6	5,391.3	366.1	−2
Cities Service	3	2,178.9	74.4	0	−27	3.4	4.7	4,456.3	127.7	2
El Paso	15	956.4	18.2	5	−52	1.9	4.1	1,890.4	39.4	4
Kerr-McGee[b]	14	911.9	50.2	2	−2	5.5	5.8	1,848.5	96.4	2
Internorth	10	721.4	22.5	−2	−44	3.1	5.4	2,174.2	129.1	16
American Petrofina	13	608.0	10.9	−15	−29	1.8	2.1	1,183.2	26.9	−14

[a] After-tax income as percentage of sales. [b] Excludes major nonrecurring earnings: Occidental Petroleum—$93 million in first-quarter 1981; Sun Co.—$135 million in second-quarter 1981; Tenneco—$73 million in second-quarter 1982; Union Oil—$24.4 million in second-quarter 1981; Kerr-McGee—$17 million charge in second-quarter 1982.

Petrochemical recession enters third year

For most of the U.S. economy, the current recession began last summer and, according to many analysts such as Du Pont's chief economist Charles B. Reeder, could yield to a modest recovery in the second half of 1982. But not for petrochemicals.

Chemical operations at petroleum companies are in the same dark corner of the economic woods as are the auto and housing industries. These petrochemicals' recession started, in terms of earnings drops, in third-quarter 1980, and it is plunging into a third year without letup. Every quarter has brought further decline for oil and natural gas firms' chemicals, which account for one sales dollar out of every four for the entire U.S. chemical industry. Oil and gas companies have the largest stake in chemicals outside basic chemical companies.

Second-quarter performance this year for chemicals in the petroleum sector was dreadful, worse again than results for basic chemical companies. The top 40 basic chemical companies had a year-to-year earnings drop of 36% and chemicals at five leading oil and gas companies had a combined after-tax earnings decline of 51%. This pulls chemical profits for these five firms down about two thirds from the last good quarter at the beginning of 1980. For the first half of 1982, earnings fell 42% from the first half of 1981.

The underlying problem for petrochemicals continues to be a wrenching dropoff in physical product volume, which exacerbates low use of plant capacity and exaggerates discounts from list prices. Exxon's volume drop in the first half was 11% in the U.S. and 7% abroad, contributing to a 57% profits plunge, says chairman Clifton C. Garvin Jr. Exxon's chemical product revenue fell 16% in the half from first-half 1981.

Much the same thing happened at Mobil and other oil companies. Mobil posted a chemical sales drop of 10% for the first six months (12% in the second quarter), leading to a 44% first-half profits decline. Mobil lays these results to lower U.S. petrochemical and phosphate rock earnings. Similarly, Shell Oil reported chemical revenue and pretax earnings drops of 14% and 60% in the second quarter and 11% and 24% for the first half. Even worse, at Gulf Oil and Atlantic Richfield, pretax chemical earnings were in the red.

Atlantic Richfield gives some startling figures on the volume loss in particular chemical categories. In aromatics, the company's year-to-year sales poundage fell 30% in the second quarter and 32% in the first half. Corresponding declines in other classes were 62% and 89% in olefins and 5% and 15% in polymers.

	AFTER-TAX EARNINGS					
	Second quarter			First half		
$ Millions	1982	1981	% change	1982	1981	% change
Exxon	$ 36	$ 96	−62%	$ 67	$157	−57%
Mobil	17	27	−37	30	53	−43
Shell Oil	6	15	−60	16	21	−24
Standard Oil (Ind.)	42	52	−19	83	91	−9
Texaco	5	27	−80	20	49	−59
TOTAL	$106	$217	−51%	$216	$371	−42%

FIRST-HALF 1982			STOCK MARKET DATA							
Change from 1981	Profit margin[a]		Earnings per share		Stock price			Price-earnings ratio July 30	Annual indicated dividend	Dividend yield, % of price
						Recent 12 months				
Earnings	1982	1981	2nd qtr	Recent 12 months	July 30	High	Low			
−38%	4.1%	5.9%	$1.02	$4.92	$26	$36	$26	5	$3.00	11.5%
−53	2.0	4.0	0.74	4.09	20¾	32	20¾	5	2.00	9.6
−45	2.7	4.0	1.17	6.79	26¾	39½	26¾	4	3.00	11.2
−62	2.5	5.6	0.77	4.65	25¼	46	25	5	2.40	9.5
−8	5.8	5.8	1.31	6.01	35½	64⅛	34⅛	6	2.80	7.9
−22	3.2	4.1	1.15	5.82	26¼	41⅜	24⅞	5	2.80	10.7
4	6.0	5.4	1.62	6.74	36¼	54⅛	33⅛	5	2.40	6.6
−6	7.3	7.0	1.23	5.36	31⅝	49¼	27⅛	6	1.80	5.7
−57	1.5	4.6	0.46	3.95	17¼	30⅜	17⅛	4	2.50	14.5
−34	4.2	6.0	0.92	4.65	25¾	47⅛	25⅜	6	2.20	8.5
−17	2.9	5.3	0.90	4.79	29⅛	48¾	28⅛	6	2.30	7.9
−28	3.8	5.3	1.14	5.02	23½	43⅝	22⅞	5	2.60	11.1
−7	14.9	15.6	1.94	7.63	28	54⅛	26⅞	4	2.60	9.3
−28	5.1	6.7	1.87	9.01	47⅜	79¾	41¼	5	2.60	5.5
8	6.8	6.2	1.14	4.58	24⅞	45⅝	24⅝	5	1.00	4.0
−24	2.9	3.8	0.95	3.11	54⅛	69⅛	23¾	17	1.60	3.0
−43	2.1	3.8	0.37	2.44	15⅛	28⅛	14⅝	6	1.48	9.8
2	5.2	5.2	0.95	4.08	26⅝	43¾	22⅝	7	1.10	4.1
−18	5.9	8.3	0.50	4.83	21⅞	36	21½	5	2.12	9.7
−24	2.3	2.6	1.01	6.08	53¼	63⅜	41½	9	3.20	6.0

against the bottom-out thesis. In its report on July business, the group says quite tersely, "There is no evidence at all of any pickup in the industrial sector." Most chemical businessmen agree in their midyear reports.

Even if the rosier view prevails and economic recovery begins soon, it will take some time to make itself felt in the chemical industry. The problem is that industries such as textiles, autos, and construction—leading chemical outlets—remain depressed, with little relief in sight. These industries are at their lowest levels in years, and even if they stir slightly, upturns will take time to restore chemicals to normal earnings.

Add to this the newfound problems in another big use area for chemicals—agriculture—and the picture gets even more dismal. Any pickup in currently depressed fertilizer use will not help chemical producers until sometime next year. Even the highly profitable pesticides market is experiencing trouble as farm income continues to sink.

Farmers apparently are forgoing many types of crop protection this year. One source says that farmers seem to be applying the cheapest pre-emergent weedkillers they can find. When crops come up, they then decide whether extra grain they may get from additional application of herbicides will be worth the cost. Many times, the answer is no.

As a result of such woebegone markets, basic chemical company earnings were off on a year-to-year basis more than 30% for the second quarter in a row. In the second quarter, combined earnings of the 40 largest chemical companies dropped 35.5% to about $921 million from the second quarter last year.

Even more important, for the third quarter in a row, sales of the 40 companies were down from the year-earlier quarter. In the fourth quarter of 1981, sales were off 1%. In the first quarter this year, they were down about 6%. Sales in the second quarter were down 7.6% to $21.2 billion.

The situation is bad enough that running 12-month chemical sales are falling. During the past year, from the third quarter of 1981 through the second quarter of 1982, sales for the 40 companies have fallen to about $74.7 billion, 2.6% below sales in the comparable period of 1980–81. At the same time earnings are off 17.2% to $3.4 billion. The result is that running 12-month profit margins have fallen to an average of 4.6% from 5.4%.

In the second quarter this year, the smaller companies on the list as usual outperformed the larger companies—or possibly just didn't do so poorly. Combined sales for the 20 larger companies amounted to $18.7 billion, 7.9% less than in the same period last year. Earnings for this group fell 35.6% to about $788 million. Average profit margin for the 20 larger firms dropped to 4.2% from 6.0%.

Among the 20 smaller, largely specialty chemical firms on the list, sales fell an average of 4.6% from second-quarter 1981 to a total of $2.47 billion. Earnings for these companies totaled $133 million, a drop of 34.7% from last year. Profit margins for this group remained considerably higher than those for the larger group, but they were falling fast. The average profit margin for the 20 smaller chemical companies in the second quarter this year was 5.4%, compared with a profit margin for this group of companies of 7.9% in the second quarter of 1981.

The second-quarter results merely reinforced earlier 1982 performance. For the first six months, earnings for the 40 companies were down 34.1% from the first six months last year to $1.84 billion. Sales for the group fell

Earnings are also down at most diversified chemical producers

	% chemical sales	SECOND-QUARTER 1982						FIRST-HALF 1982		
		Sales	Earnings	Change from 1981		Profit margin[a]		Sales	Earnings	Change from 1981
		($ millions)		Sales	Earnings	1982	1981	($ millions)		Sales
Du Pont	34%	$8472.0	$247.0	4%	0%	2.9%	3.1%	$16,761.0	$497.0	3%
General Electric	4	6632.0	465.0	−5	7	7.0	6.3	12,655.0	842.0	−3
U.S. Steel[b]	10	5100.0	4.3	35	−97	0.1	4.4	10,100.0	84.2	40
Dart & Kraft	11	2497.7	105.3	−4	−19	4.2	5.0	4,937.1	202.2	−1
Eastman Kodak	23	2430.5	248.3	1	−13	10.2	11.8	4,678.1	429.6	−1
Goodyear Tire & Rubber[c]	12	2290.2	63.3	−3	−29	2.8	3.7	4,437.5	108.9	−3
Beatrice Foods[c]	5	2277.7	71.3	2	−7	3.1	3.5	4,505.3	145.3	3
3M	15	1687.0	158.6	1	−8	9.4	10.3	3,353.0	311.1	3
Georgia-Pacific[b,c]	14	1415.0	71.0	−2	29	5.0	3.8	2,614.0	96.0	−6
Aluminum Co. of America[c]	11	1239.5	15.1	−5	−81	1.2	6.2	2,245.3	39.0	−6
Borden[c]	32	1039.0	32.0	−14	−20	3.1	3.3	1,967.2	49.2	−13
Martin Marietta	14	909.7	40.2	3	−34	4.4	6.9	1,694.3	56.0	6
Pfizer	13	875.3	80.6	10	25	9.2	8.1	1,683.7	168.8	5
Diamond Shamrock[c]	34	857.7	31.9	6	−42	3.7	6.8	1,648.8	61.1	−2
Borg-Warner	24	844.2	46.7	5	11	5.5	5.2	1,581.5	83.0	1
Kaiser Aluminum	17	814.9	−30.0	−9	def	def	7.7	1,548.7	−54.9	−10
Esmark	18	814.6	28.2	3	−13	3.5	4.1	1,539.8	41.7	5
Merck	23	774.6	111.3	4	3	14.4	14.6	1,518.1	221.1	3
Eli Lilly	18	708.2	93.2	13	22	13.2	12.2	1,571.4	228.8	9
Northwest Industries	6	671.5	76.7	−14	27	11.4	7.7	1,465.9	171.3	−1
NL Industries	21	632.4	73.1	3	0	11.6	11.9	1,297.7	166.5	13
General Tire & Rubber[c]	19	585.6	25.0	4	36	4.3	3.2	1,042.3	21.2	−2
Uniroyal[c]	28	541.0	8.1	−14	−71	1.5	4.4	1,026.1	9.3	−12
Upjohn	17	475.8	38.4	−7	−14	8.1	8.7	936.1	81.3	−6
Emhart	16	459.7	18.2	4	−14	4.0	4.8	908.7	38.3	4
Engelhard[c]	11	447.4	16.3	3	−21	3.6	4.8	883.3	30.5	−22
Koppers	34	443.4	7.6	−18	−53	1.7	3.0	798.7	−3.1	−17
Cabot	30	404.6	24.6	−3	−17	6.1	7.1	823.7	51.4	0
Tyler	36	221.6	3.4	18	−59	1.5	4.3	429.0	3.4	31
Big Three Industries	32	194.7	22.1	−3	−17	11.3	13.2	407.5	48.6	2

a After-tax income as percentage of sales. b Earnings include major nonrecurring items. c Excludes major nonrecurring items: Goodyear—$17.2 million in second-quarter 1982; Beatrice Foods—$31.9 million in second (first fiscal) quarter 1982; Georgia-Pacific—$130 million in first-quarter 1982; Aluminum Co. of America—$19.9 million in first-quarter 1982; Borden—$10.4 million in second-quarter 1982 and $17.6 million in first-quarter 1982; Diamond Shamrock—$35.5 million in first-quarter 1982; General Tire—$4.9 million in second-quarter 1982, $30.8

6.8% to $42.1 billion. As a result, profit margin was down to 4.4% from 6.6% in the first half of 1981.

Again, the smaller firms performed less poorly than the larger companies. First-half sales for the 20 larger firms dropped 6.9% from a year before to $37.2 billion, and earnings dropped 34.6% to $1.58 billion. Profit margin fell to 4.3% from 6.0%.

At the 20 smaller firms, sales in the first six months of 1982 dropped 5.5% from a year earlier to $4.88 billion. Earnings for this group fell to about $264 million, 31.3% below levels in the first six months of 1981. As a result, profit margin for the group dropped to 5.4% from 7.4% in the first half last year.

These horrendous results have caused many companies to lower various budgets for the year, notably capital spending. For example, B. F. Goodrich has cut about $150 million from its capital budget for 1982, although chairman John D. Ong says that the company is continuing most key expansions and modernizations in growth businesses. Goodrich also has taken other cost-cutting steps, including temporary salary and vacation reductions and increased attention to management of working capital.

Air Products says that it is adjusting to the recession by reducing capital expenditures, curtailing discretionary expense programs, and further emphasizing energy efficiency and productivity improvements. Chairman Edward Donley also says, "We are proceeding with major investments in industrial gas facilities under long-term contract but are trimming $25 million to $50 million in spending for distribution and support equipment from this year's $400 million capital program."

At Dow Chemical, executive vice president and chief financial officer Robert M. Keil says that the company has made substantial progress on internal cost controls. A freeze on salary increases and other economies has saved some $150 million in pretax earnings in the past six months.

Chemical executives are unsure as to what lies ahead, but most feel that even if a recovery comes late in the year, it will not be so substantial as they would like.

Pennwalt chairman Edwin E. Tuttle says, "We're all aware that the U.S. is in a deep and continuing recession, and our results clearly reflect that condition. We remain confident, however, that our government is on the proper course and that a recovery will be evident by the end of the year."

Cyanamid chairman James G. Affleck sees no indication that economic

FIRST-HALF 1982			STOCK MARKET DATA							
Change from 1981	Profit margin[a]		Earnings per share		Stock price			Price-earnings ratio July 30	Annual indicated dividend	Dividend yield, % of price
				Recent		Recent 12 months				
Earnings	1982	1981	July 30	12 months	July 30	High	Low			
−12%	3.0%	3.5%	$1.03	$5.53	$30¼	$47⅞	$30	5	$2.40	7.9%
6	6.7	6.1	2.05	7.48	65¾	69⅞	51⅛	9	3.40	5.2
−81	0.8	6.0	0.05	3.27	17¾	32¾	17¼	5	2.00	11.3
−13	4.1	4.6	1.93	6.89	53¾	54¾	44⅝	8	3.60	6.7
−19	9.2	11.3	1.52	6.99	75⅝	78⅝	60⅝	11	3.00	4.0
−25	2.5	3.2	0.85	2.83	23¼	26	15⅞	8	1.40	6.0
−2	3.2	3.3	0.65	2.81	20	22¼	16¾	7	1.50	7.5
−9	9.3	10.5	1.35	5.48	53⅛	57⅜	48	10	3.20	6.0
−10	3.7	3.8	0.66	1.38	14⅞	26⅛	13¼	11	1.20	8.1
−79	1.7	7.0	0.19	1.84	23½	29½	21⅞	13	1.80	7.7
−32	2.5	3.2	1.08	4.50	33	35¾	26¾	7	2.22	6.7
−44	3.3	6.3	1.13	4.27	23⅞	40½	22¼	6	1.92	8.0
21	10.0	8.7	1.04	3.96	55¾	62	40	14	1.84	3.3
−47	3.7	6.9	0.51	2.81	17⅜	37⅜	17¼	6	1.76	10.1
8	5.2	4.9	1.10	4.18	25⅜	29¼	21⅛	6	1.40	5.5
def	def	7.9	−0.70	−1.38	12¼	21⅜	12	def	0.60	4.9
−7	2.7	3.0	2.19	7.37	41½	55½	39⅞	6	1.84	4.4
0	14.6	15.0	1.51	5.39	69⅞	93⅜	64¾	13	2.80	4.0
14	14.6	14.0	1.23	5.30	54¾	65¼	45¼	10	2.60	4.7
57	11.7	7.4	3.77	12.86	45	80½	46¼	4	4.40	9.8
27	12.8	11.4	1.12	5.18	16⅜	48⅝	16⅝	3	1.00	6.1
−12	2.0	2.3	1.06	3.02	22½	26⅝	17⅞	7	1.50	6.7
−76	0.9	3.3	0.25	0.59	7⅜	9¾	5⅞	13	0	0
−20	8.7	10.2	1.28	5.36	39	59⅜	38	7	2.28	5.8
39	4.2	3.1	1.50	6.74	28¾	36¼	26⅛	4	2.40	8.3
−14	3.7	3.1	0.60	2.47	20⅝	25½	17	8	0.56	2.7
def	def	1.3	0.20	1.01	11½	23⅜	11¼	11	1.40	12.2
−15	6.2	7.3	0.77	3.12	16¾	35	16¼	5	0.92	5.5
−74	0.8	4.0	0.36	1.91	13⅞	25¾	12⅛	7	0.60	4.3
−8	11.9	13.2	0.52	2.48	18	35¾	16	7	0.72	4.0

million charge in first-quarter 1982, and $4.4 million charge in first-quarter 1981; Uniroyal—$18.0 million in first-quarter 1982; Engelhard—$5.2 million in second-quarter 1981. **def** = deficit.

conditions will change quickly. He does say, however, "We do believe there will be some improvement later in the year. When this occurs, we are confident that our basic competitive strength will allow us to resume our growth at a rapid pace."

And Alexander F. Giacco, chairman and president of Hercules, says, "As to an anticipated recovery, the industry segment of the economy which is capital-intensive will show progress once the federal government resolves its financial problems. The budget situation has caused shortages of capital and, consequently, extraordinarily high interest rates. The resolution of this problem is necessary to restore confidence not only in financial markets but in consumer attitudes as well."

At Du Pont, which is benefiting hugely this year from its Conoco acquisition as a counterbalance for chemical profit declines, chairman Edward G. Jefferson still takes a cautious view toward the rest of 1982. "In the third quarter thus far, our business shows no evidence of recovery and has declined in some sectors which are affected by customer vacation shutdowns. We expect to see modest improvement in general economic activity in the fourth quarter. An end to inventory liquidation, the personal income-tax cut, and the lower rate of inflation should all help bring improvement. However, substantially lower interest rates appear to be a prerequisite for vigorous recovery."

Du Pont so far can laugh at critics of its mammoth Conoco takeover last fall. A $97 million after-tax second-quarter income turnaround at Conoco's coal operations plus a $46 million drop in interest and other corporate expenses largely balanced a $150 million earnings falloff in the old Du Pont company operations. The Conoco petroleum operations, unlike oil companies in general, had slightly rising earnings. As a result, Du Pont's second-quarter earnings, on a pro forma comparison with combined Du Pont-Conoco results for second-quarter 1981, came out just about even with 1981—one of the best performances of any large company.

Even so, Du Pont's chemical earnings figures underscore the chemical industry's financial bath. In the company's three main chemical groups, second-quarter after-tax operating income fell 30% in polymers, 44% in agricultural and industrial chemicals, and 82% in fibers.

In sum, the deep chemical recession has carved a second miserable quarter for 1982 this spring and will make another one this summer. An upturn is not yet in sight. □

Losses plague Canadian chemical companies

C-I-L is the only one of the five big chemical companies that posted a profit in this year's first half; together, the five lost $3.6 million

Canada continues to languish in its deepest economic slump since the 1930s. For the country's chemical industry, the impact of that slump is unmistakably severe.

Sales are down. Profits have disappeared for many companies. Those few companies that have managed to remain in the black for the first six months of the year have done so only by the slimmest of margins.

The combined results of five major Canadian chemical companies charted by C&EN underscore the tailspin that the industry has been in for the past two years. The companies are C-I-L, Celanese Canada, Du Pont Canada, Polysar, and Union Carbide Canada.

In the second quarter of 1980, the combined earnings of these companies hit a record $79.2 million (Canadian). By the second quarter of last year, those earnings dipped to $66.5 million.

This year, those same five companies registered a painful loss of $4.3 million in the second quarter. For the first six months as a whole, their combined results amounted to a loss of $3.6 million.

C-I-L's chairman and chief executive officer Wilfred J. Mandry complains, justifiably, about the adverse effect of the recession and continuing high interest rates on his company's performance. Indeed, C-I-L's six-month sales were down 3% and earnings were off a hefty 50%.

Nevertheless, C-I-L is one of the lucky ones. It at least has managed to show a profit so far this year. That's something that has eluded the other four of the five companies. Polysar was the only one of the five to boost sales over last year's first half, but it still suffered a $10.2 million loss for the first six months of this year. Celanese Canada sported a $2.5 million deficit; Du Pont Canada's was $1.9 million; and Union Carbide Canada's was $5.7 million.

Throughout the industry, the story is the same: poor sales volume and inability to pass along cost increases in the form of higher prices.

Particularly outspoken is Union Carbide Canada's chairman John S. Dewar. He blames Canada's energy policy for increasing raw material costs to crude oil-based petrochemical producers 15% in the past nine months while costs on the U.S. Gulf Coast declined. And he warns that the future of the Canadian petrochemical industry depends on the government's recognizing the industry's highly competitive international nature.

Throughout the industry, too, reactions to sharply lower sales and income losses are similar. Companies are curbing capital spending to conserve cash. Some projects are being delayed, others scrapped entirely.

Many firms are closing plants or at least cutting production to trim inventories or to keep in step with sharply lower demand. Layoffs are commonplace. Dividends are being cut or eliminated. Many workers are finding their salary increases restricted—or rescinded.

It's hard to imagine that things could get worse. But, given Canada's economic climate and poor recovery prospects, that's exactly what could happen.

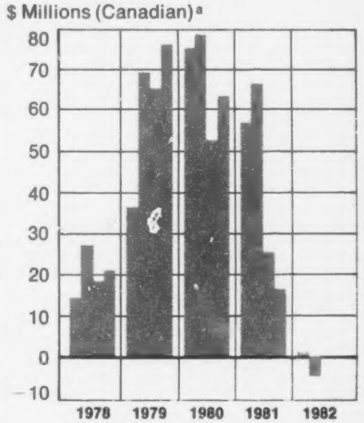
C-I-L's Mandry says that the adverse impact (on sales and earnings) of the country's poor economy will be "accentuated" in the third quarter. One reason: Many of C-I-L's resource-oriented customers plan long summer shutdowns. Another: The construction industry is in the doldrums.

James E. Newall, chairman and chief executive officer of Du Pont Canada, agrees that the outlook for the third quarter is poor. He expects his company to operate at less than 50% of capacity during July and August.

Some Canadian economists have said that they see mildly encouraging signs in recent economic developments. But they are a minority. Optimism is a rare commodity in Canada these days, particularly in the chemical industry.

Earl Anderson, New York

Combined earnings drop into the red



a After-tax earnings of five largest publicly reporting Canadian chemical companies—Celanese Canada, C-I-L, Du Pont Canada, Polysar, and Union Carbide Canada.

First half is financial disaster for Canadian chemical firms

	FIRST SIX MONTHS, 1982					
$ Millions (Canadian)	Net sales	Change from 1981	Net income[a]	Change from 1981	Profit margins[b] 1982	Profit margins[b] 1981
C-I-L Inc.	$ 595.8	−3.2%	$16.7	−50.1%	2.8%	5.4%
Celanese Canada	155.7	−19.4	−2.5	def	def	6.6
Du Pont Canada	511.6	−14.2	−1.9	def	def	4.8
Polysar Ltd.	704.4	2.6	−10.2	def	def	3.3
Union Carbide Canada	356.6	−15.0	−5.7	def	def	6.4
TOTAL	$2324.1	−7.5%	$−3.6	def	def	4.9%

a Net income from continuing operations, excluding extraordinary gains or losses. b Net income as a percentage of sales. def = deficit.

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Chemical & Engineering NEWS

August 23, 1982

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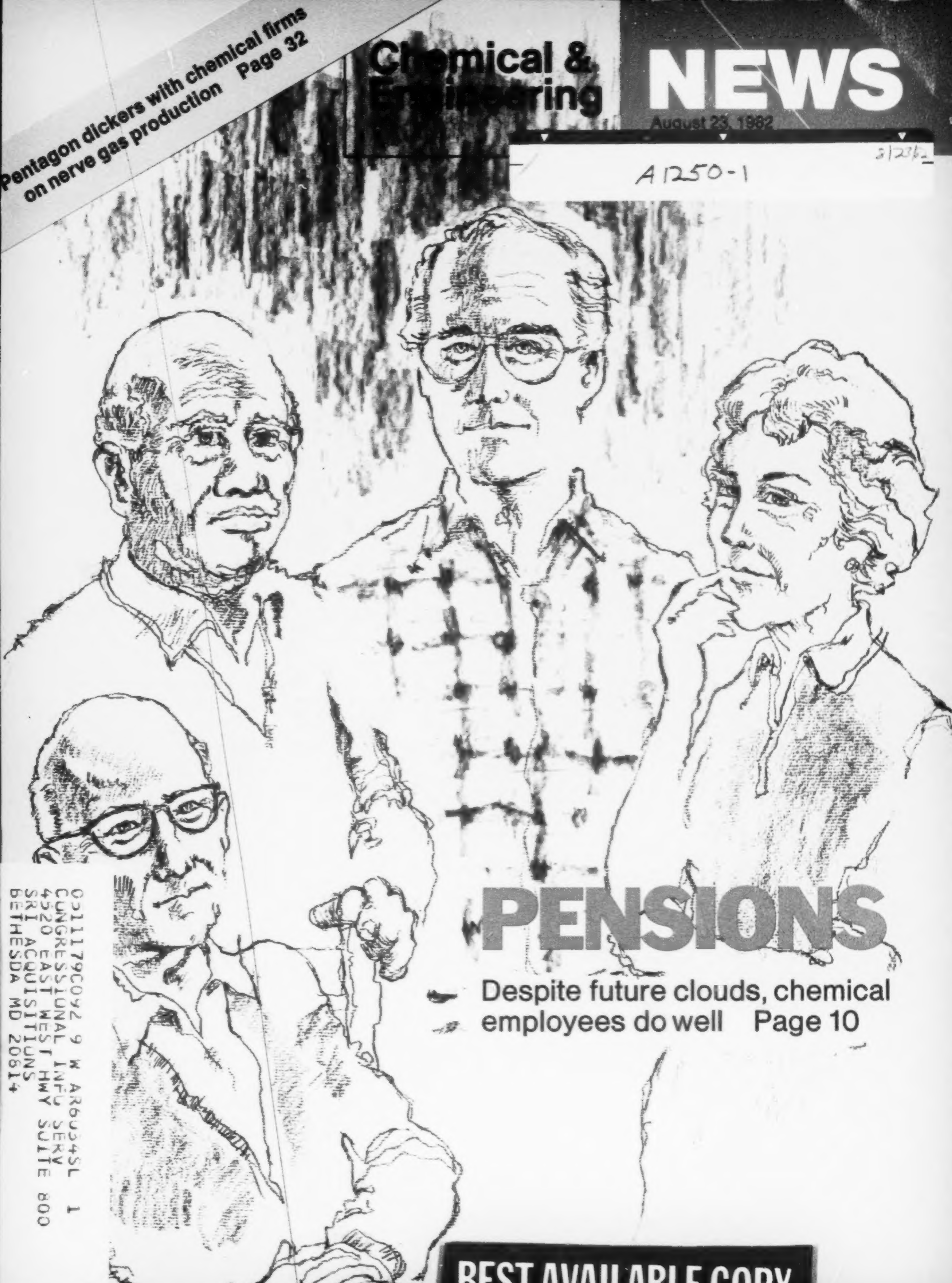
Pentagon dickers with chemical firms on nerve gas production Page 32



PENSIONS

Despite future clouds, chemical employees do well Page 10

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4 Letters
5 Editor's Page

Concentrates

16 Business
30 Government
43 Science/Technology

The Departments

39 New Products
54 Meetings
56 Newscripts

News of the Week

- ***Although the fertilizer market has been weak*** *this year and inventories have piled up, industry experts say oversupplies aren't so bad as they look.* ***Page 6***
- ***Appeals court disallows*** *EPA's expansion of bubble concept to let plants average pollutant emissions in areas not meeting air quality standards and to include an entire plant as a new pollution source.* ***Page 6***
- ***Occidental Petroleum's bid for Cities Service*** *is temporarily in limbo; if merger comes about, combined sales of about $24 billion will put the joint company among the top 10 U.S. chemical producers.* ***Page 7***
- ***Better understanding of Lesch-Nyhan syndrome,*** *which causes excess production of uric acid, may be possible with the isolation of the gene that causes it.* ***Page 8***
- ***Chemical stocks were among the gainers*** *when an emotional outburst typical of Wall Street followed a prediction that interest rates soon would fall sharply; among big winners were Union Carbide and Monsanto.* ***Page 8***

News Focus

- ***Collection on retirement pensions*** *appears certain for chemical industry personnel, but changing demographics may paint a different future picture for pension plans and alternatives may be sought.* ***Page 10***

Business

- ***Hydrazine producers*** *counting on product's wide range of uses to pull through the recession and make a fast comeback despite current soft market.* ***Page 23***

International

- ***Developing nations' chemical exports*** *have been rising faster than those in industrialized countries.* ***Page 26***

Government

- ***Army's search for firms to make nerve gas chemicals*** *finds small firms agreeable; large companies consider manufacture unattractive economically.* ***Page 32***
- ***President Reagan's science policy attacked*** *by Republican Sen. Harrison Schmitt; cites neglect of space science, health care, agriculture, transportation.* ***Page 40***

Science

- ***ZTP,*** *a member of the cell-growth regulators called alarmones that help bacterial cells respond to metabolic stress, discovered by UCB biochemists.* ***Page 44***
- ***Seeking the methylene radical in interstellar space*** *becomes more intense as clues to its rotational transition are found.* ***Page 45***

FERTILIZER SLUMP NOT SO BAD AS IT SEEMS

August 1982 would be an excellent time to see silver linings in the U.S. chemical economy, since there is such an abundance of clouds and few even half-confident forecasts of recovery. Possibly Wall Street has done just that in last week's stock price surge (see page 8). And in one of the most disappointing chemical markets of the past year, fertilizer, another noted industry analyst is trying to see the bright side.

Economist Edwin A. Harre and colleague Norman L. Hargett of Tennessee Valley Authority's National Fertilizer Development Center argue that the oversupplied fertilizer scene, tracked through key inventory data, isn't quite so bad as it looks. They don't deny that the U.S. fertilizer market, after a year with an 11% drop in domestic use and an 18% sag in exports as measured by the Fertilizer Institute (C&EN, Aug. 9, page 7), is weak. Great tonnages of inventories have piled up, reinforcing problems in prices and profits bemoaned by producers in midyear reports.

At a TVA fertilizer conference in St. Louis, Harre noted, for example, that nitrogen stocks peaked in 1978, with inventories equivalent to about 31% of total production. Stocks decreased slowly, to about 18% by 1981, but then rose again to 21% in April 1982. Inventories have been a problem, and a primary cause of softness in prices, Harre concedes.

From another perspective, however, nitrogen inventories really aren't that far out of line. The April level was above the normal 10 to 20% range, but only by a little. And the spring planting season was up to a month late in many parts of the U.S. "If the fall market should come early this year, or the nitrogen export market again becomes active, or the industrial market begins to recover, there is little excess supply available from inventory," Harre comments.

Many ammonia plants have closed in response to higher inventories and falling prices. However, Harre says, that isn't a short-term trend. There's been a steady decline in U.S. ammonia capacity, from a peak of 22 million tons in 1978 to a current level of about 20 million tons. Even so, with recent and pending expansions in Canada, Mexico, and Trinidad, the U.S. will have an ample potential supply within the Western Hemisphere.

Potash inventories reach new high

	Inventories as percentage of production[a]		
	1982	1980	1978
Nitrogen	21%	20%	31%
Phosphorus	8	8	7
Potash	26	11	20

a As of April 30. Source: Tennessee Valley Authority

Similarly, April phosphate inventories exceeded 800,000 tons of P_2O_5, compared to the 300,000- to 400,000-ton levels of 1973 and 1977, Harre says. However, that tonnage—about 8% of total production—represents only the normal inventory level needed at the beginning of the spring fertilizer season. With a return to normal demand, the current inventory would be depleted quickly, leading to another runup in prices until production could be expanded to meet the demand.

Responding to large export increases in the late 1970s, many phosphate producers began expansion programs. But although most of the new plants have been completed, the increase in net capacity has been small because of recent plant closings, Harre says. The industry has ample idle capacity; any long-term shortage is unlikely unless this idle capacity is abandoned before the market improves. In the short term, however, the industry may see shortages brought on by producer miscalculations of total U.S. and export needs, Harre adds.

Potash producers have had the biggest changes in inventory levels, Harre says. Between August 1981 and April 1982 potash stocks more than doubled, from 1.2 million tons of K_2O to more than 2.5 million tons. During the year, shipments within the U.S. were down about 14%, and exports declined more than a third. April inventories—about 26% of total production—were "higher than desired" and exceeded earlier peaks in 1971 and 1976. In both those instances, Harre notes, four years later stocks had dropped from a high of 25% to well under 10% of production.

Although there is ample supply to avert any shortage in the coming year, Harre says that producers have begun to react to the situation. Production cutbacks in the U.S. and Canada in recent months total almost 1 million tons, and some expansion plans have been delayed. In May and June, potash stocks declined more than 500,000 tons. □

Court bursts EPA's expanded bubble idea

A federal appeals court in the District of Columbia ruled last week that the expansion of the "bubble" concept made by the Environmental Protection Agency last October is not permissible. The decision by the three-judge panel, written by Judge Ruth Bader Ginsburg, says that EPA's changes are against the intentions of the Clean Air Act as written by Congress.

The bubble idea began in the Carter Administration to be used in areas that already had attained the air quality standards. An industrial plant in those areas could average emissions from all units within the plant as a pollution source and add new units by cutting pollutants somewhere else, as long as the total pollution did not increase.

This concept was expanded by EPA Administrator Anne M. Gorsuch last year, who believed there were so many restrictions under the current plan that almost no company could qualify. Gorsuch would permit bubbles to be used in areas that had not met the air quality criteria, and changed the definition of a new pollution source to be an entire plant, not just a new boiler or other unit at the existing site.

The change, as could be expected, had much industrial support, including the Chemical Manufacturers Association, the American Petroleum Institute, the American Iron & Steel Institute, and General Motors.

But environmental groups took umbrage, and a suit to stop the change was filed by the National

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Chemical industry pensions in good shape

The vast majority of workers in the industry can be reasonably sure of someday receiving their pensions, but changes in demographics may mean shifts in emphasis

Patricia Layman
C&EN, New York

As a general statement, the numbers sound grim: About half of all private-sector employees are covered by no pension plan, and half of those who are covered have no vested benefits at their current job.

But contrast those grim statistics with these: 97% of all chemical companies in the most recent U.S. Chamber of Commerce study reported paying pension premiums; by another estimate, more than 90% of chemical company employees are covered by plans; the chemical industry's net assets for pensions are more than 99% of its total vested-benefit obligations.

In short, pensions in the chemical industry are in remarkably good shape, and the vast majority of workers in the industry can be reasonably sure of someday receiving their pensions.

Pension funds now account for more than $900 billion, for all private pensions, and that sum is rapidly nearing the $1 trillion mark, about triple what it was a decade ago. The chemical industry accounts for little less than $20 billion of that, with the major chemical producers' plans totaling nearly $17 billion. In fact, in its yearly ranking of pension funds, *Institutional Investor*, a financial investment magazine, pegged Du Pont's pension plan the sixth-largest plan in the country. The magazine calculates Du Pont's pension assets at $5 billion, less than the $6.2 billion listed in the firm's annual report but enough to fix the company solidly with General Electric, General Motors, Ford Motor Co., and U.S. Steel. American Telephone & Telegraph topped the list at $35.5 billion in its pension fund.

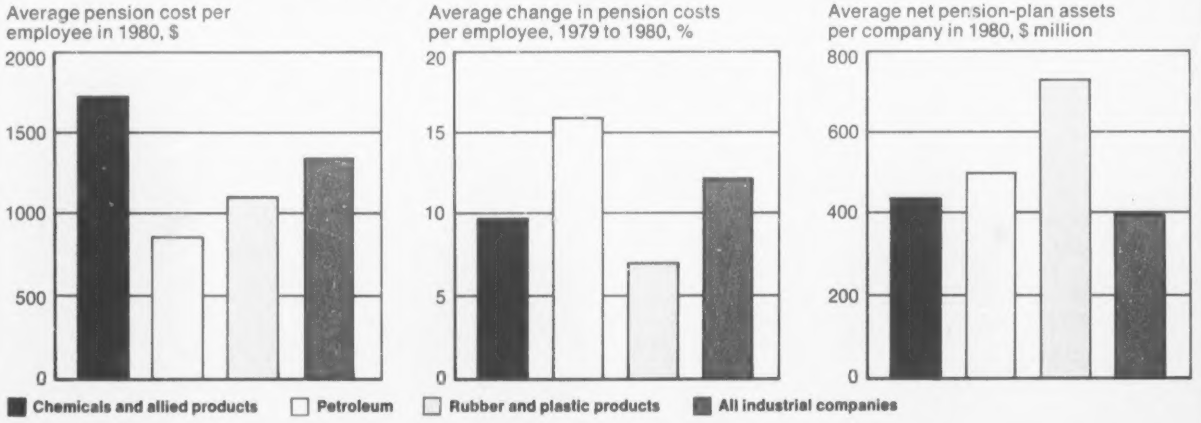
Major chemical companies also account for more than 90% of the more than 920,000 employees estimated to work in the U.S. chemical industry last year. Given the general pension-plan coverage the major companies offer—including opening pension plans even for part-time employees—and the general matching of these plans by other firms to maintain their competitiveness as employers, these factors boost the overall percentage of chemical workers covered by pensions.

Romig: contain benefit costs.

All this comes as no surprise to Michael J. Romig, director of the Human Resources & Employee Benefits Section of the U.S. Chamber of Commerce.

"The chemical industry is not, for the most part, characterized by small firms," he says. "For the large com-

Chemical companies' average cost per employee tops industry averages



Source: Johnson & Higgins

panies, the 'pension issue' is whether they have taken on too much in terms of benefit costs, and how they can contain them."

Nor does it surprise pension-plan managers in outside companies such as insurance firms, or consultants, who try to gauge the soundness of pension plans. Annual reports provide a general look at plan funding, under the dictates of federal regulations and accounting standards, showing plans' net assets available for pension benefits and the total accrued benefits. Different measurements are used for the two categories, so direct comparison cannot be made—if not apples and oranges, then at least Jonathans and Grimes Goldens. But they can give rough indications of what surveys by employee-benefit consultants pin down more precisely.

For example, in its survey for 1980, issued earlier this year, New York City-based Johnson & Higgins determined that net assets as a percentage of total accumulated benefits for chemical companies was 98.4%, which compares favorably to the 97.6% in the petroleum industry, and the 76.5% reported for rubber and plastics producers.

Other measurements throughout the Johnson & Higgins survey, and in Chamber of Commerce surveys, give similar results. Overall, the chemical industry, in terms of benefit performance, ranks second only to the petroleum industry in manufacturing rankings, with "manufacturing" as a category outperforming the nonmanufacturing sector with its many service-oriented, smaller companies—just the kind of companies that tend not to have pension plans.

For chemical employees, then, the keys to ensuring a pension are to work for a larger company, and to work there long enough.

Since the passage in 1974 of the Employee Retirement Income Security Act (ERISA), the time allowed for an employee to obtain vested rights to a pension has been trimmed, and the trend is toward even shorter vesting periods. But some people think it's still not short enough. The working world today clearly is different from the days when the concept of a pension originated as a reward for long and faithful service. Statistics now indicate that, on a national basis, the average employee changes employers every four years. As a result, the concept of a pension is shifting to that of deferred wages—wages held back from the employee during his or her working

How pension fund liabilities are determined

Under Internal Revenue Service rules, companies are permitted to amortize their past-service costs for pension liability funding over any time period from 10 years to 30 years (or 40 years, for new plans). To determine how much a company would owe each year, then, such depreciation either would condense or stretch the amounts owed and the payments.

The most conservative method of funding would be to amortize the costs over the minimum 10 years—each year's payment would be roughly one tenth the total.

Correspondingly, the most liberal accounting procedure would be amortization over 30 years—a longer time over which to spread a given amount of payment. With such a liberal plan, however, chances are that for older workers—those 50 years of age, for example—a company still might be funding benefits for such workers after their deaths.

Many pension-plan administrators believe that a responsible midpoint in that continuum is amortization of costs over the working life of the employee, on an aggregate level. It's more than 10 years, but much less than 30 years. That method, planners feel, helps ensure that a company has the funds to pay for each worker at retirement. The method is conservative without being stuffy, adds one administrator, but "it's not off the wall."

Another means to measure pension funding lies in the accounting requirements for asset disclosure in corporate annual reports. This becomes a snapshot of what the company's liabilities are today, and whether it is ahead of or behind the game. Generally included are statements of the net assets available for benefits, and the actuarial present value of accumulated plan benefits, including those vested and nonvested. There are several weaknesses to such reporting. First, there is a major variable in the calculations, in the rate of return which is assumed. For example, if a company assumes a 20% rate of return, it needs very few assets to start with—on paper. Therefore, by pushing up the interest-rate assumptions, a company can understate its true liabilities, and improve what otherwise might seem a lackluster underfunding of a plan. Second, such reporting is, in essence, frozen into time, and doesn't allow for future wage increases. On balance, however, it's acceptable for a snapshot of today.

Most major firms have sufficient assets to cover benefits

$ Millions	Net pension-plan assets available for benefits	Vested accumulated plan benefits (present value)	Nonvested accumulated plan benefits (present value)	Assumed rate of return, %
Du Pont	$6198	$4195	$ 77	10.4%
Dow Chemical	1026	887	188	8
Monsanto	1358	1221	157	7.5
Union Carbide	1683	1239	108	9
Celanese	529	271	11	8.25
W. R. Grace	312	215	17	6.4
Allied	779	822	47	8
Hercules	505	371	17	8
American Cyanamid	541	462	8	8.5
Rohm & Haas	358	265	2	8.5
Stauffer Chemical	234	143	20	7
Ethyl	291	223	18	6
FMC	529	432	33	8
Air Products	136	82	15	7
International Minerals	120	124	16	7
Olin	362	306	21	7
B. F. Goodrich	468	549	58	9
PPG Industries	529	488	57	9
Williams Cos.	62	48	3	7
Reichhold Chemicals	35	32	3	8.5
Lubrizol	34	24	2	6
National Distillers	251	175	12	12
Nalco Chemical	81	60	6	7

Source: Company annual reports, 1981

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ERISA is designed to safeguard employees' pension rights

For pension planners, ERISA has been the password for the past eight years, since the Employee Retirement Income Security Act (ERISA) was passed. Created in reaction to well-publicized abuses of pension rights—employees fired a day or week before becoming eligible to draw pensions, for example, or companies folding and leaving no assets to pay pension obligations—ERISA set out to safeguard the pension rights of employees by ensuring that companies strengthen the funding of and liberalize rights of participation in their pension plans.

Employee-benefits lawyers and pension-plan administrators probably aren't overstating the case when they call ERISA "incredibly complex." As one such attorney puts it, "It created my job overnight." Grossly simplified, however, ERISA boils down to four major points:

- Employee vesting.
- Employers' fiduciary responsibility.
- Pension-plan disclosure.
- Creation of Pension Benefit Guaranty Corp. (PBGC).

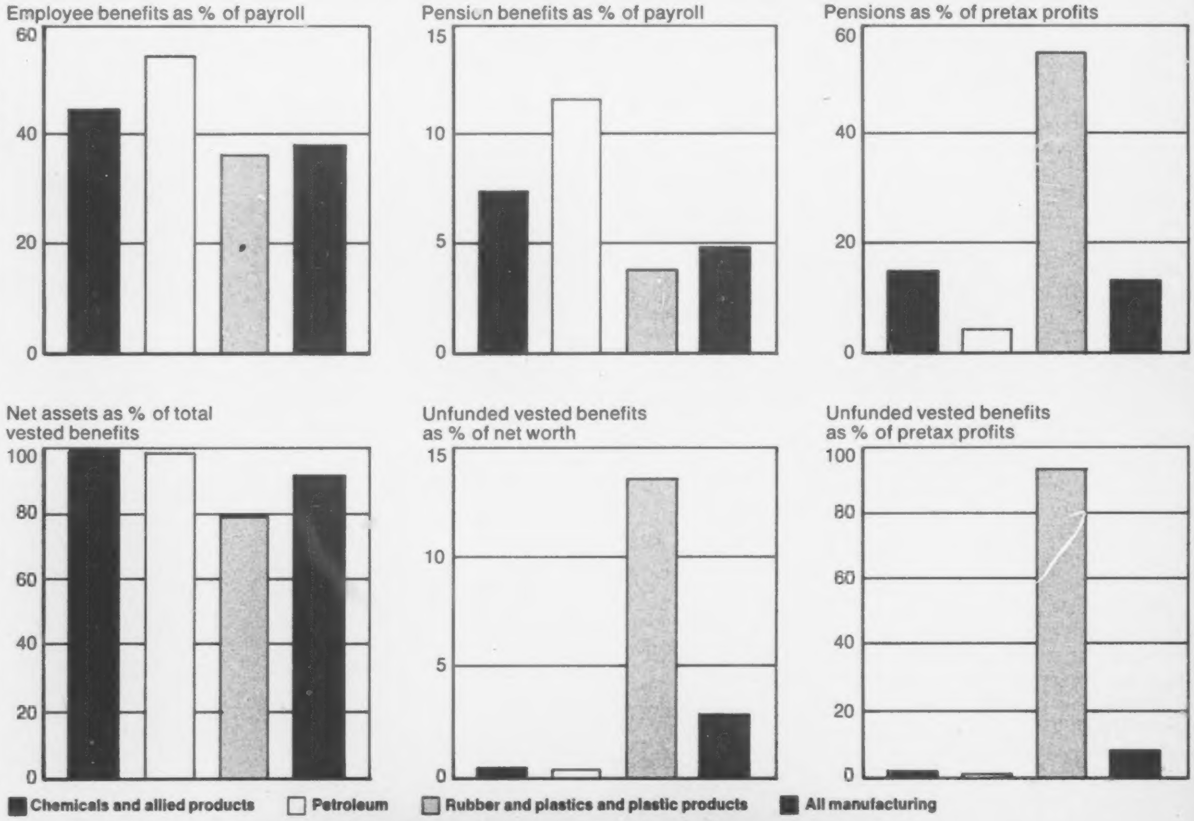
Under the employee vesting provisions of ERISA, there are three basic forms of vesting. The first, a "cliff-10," provides for no vesting up to 10 years of service, after which the employee must be 100% vested. The second, a graduated vesting program, provides 25% after five years of service, increasing 5% per year for the next five years and 10% for the next five years—that is, 50% vesting after 10 years, and 100% after 15 years. The third method, called the rule of 45, gives an employee 50% vested interest after either 10 years of service or when the combination of years of service (a minimum of five) and the employee's age totals 45. After that, the employee's vesting increases 10% per year for the next five years to reach full vesting.

Under ERISA, a person administering a pension plan must act, as a fiduciary, solely in the interest of the plan participants and beneficiaries. He or she must use the diligence and care that a "prudent person" would use, diversifying investment portfolios, for example, to minimize the risk of all-in-one-basket losses, unless it would be clearly imprudent to do so. Both the corporation sponsoring the plan, and the plan administrator, personally, are responsible for pension plan performance under this provision.

Also as part of their duties, plan administrators must ensure plan disclosure to two groups: to the participants, and to the federal government. Plan participants, for example, must be given a summary description of the plan, its amendments and annual report, and a statement of benefits. Similar but expanded data must be provided to various government agencies.

One of the major government agencies involved is PBGC, created by ERISA as a sort of insurance program to guard against pension-plan failures. It was designed to fund a company's pension

Chemical companies' pension outlays are higher than for all manufacturing



Sources: U.S. Chamber of Commerce, Johnson & Higgins

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plan in the event that the economy went bankrupt, from funds kicked in by all companies covered by ERISA. The initial premium was 50 cents per employee. Even industry plan managers agree that amount was woefully inadequate, so the premium was kicked up to $2.60 per employee. That level, too, is probably low for building from scratch a pool of funds to cover potential plan failures. But because there is little or no experience on what the costs should be, there is little agreement on what the new premium should be. PBGC, for example, is pushing for a $6.00 rate; industry wants something less than that.

And both sides to the argument—industry and PBGC—are fearful of what would happen to premiums if the courts decide, in several cases under way, that PBGC must take over and fund pension plans of companies which had unfunded pension-plan obligations and then terminated the plans. Such a burden falling on PBGC could cause premiums to skyrocket.

life that eventually will be paid back as pensions. And if that is so, argue consumer activists, why should there be any vesting time at all? This point, which was made by at least one Presidential commission on pensions (appointed by Carter, disavowed by Reagan), is a spur toward gradually shortened times. Or pensions should be made portable, the argument continues, with pension rights transferable from one company to another, which they now are not.

For workers at a small company, it's probably a tossup as to whether the company has a pension plan. Those that have must live with the dictates of ERISA, or, also under its provisions, terminate the plan. For a small company with a young workforce, in particular, plans other than a pension plan can offer even more to an employee, besides saving the company the hefty costs associated with ERISA regulations and compliance. Alternatives could be a profit-sharing plan, or company-encouraged individual retirement accounts (IRAs), or salary-reduction savings programs.

In some cases, if a company is having financial difficulties, termination of a pension plan could mean the difference between folding and continuing; the funds that would be put into the plan could be used, instead, as working capital. One method of innovative termination could entail terminating the plan, buying employees annuities bearing a high interest rate as a replacement, then using excess cash for daily business operations. At any rate, for a small company starting up—or even one already in business—"It's foolish to set up a pension plan these days," one employee-benefits attorney says.

Ironically, small companies may benefit in the long run from pension legislation such as ERISA, some plan managers believe. With the pool of pension funds so high, there may, in the short run, be some concentrating of investment funds in large corporations. Rather like Markovnikov addition, big bucks flock where big bucks have gone before. Managers used to dealing with large sums from large pension plans might feel more comfortable investing in large companies.

However, ERISA directs plan managers to diversify portfolios whenever it is prudent to do so. And in a world of high inflation, managers will seek to maximize their return on investment while maintaining safety. For them, the larger the bulk of the cushion from conservative secured investments, the more—10% of a total fund, perhaps—can be put into more speculative but faster-growing investments such as real estate, metals, or even such oddities as fine artworks.

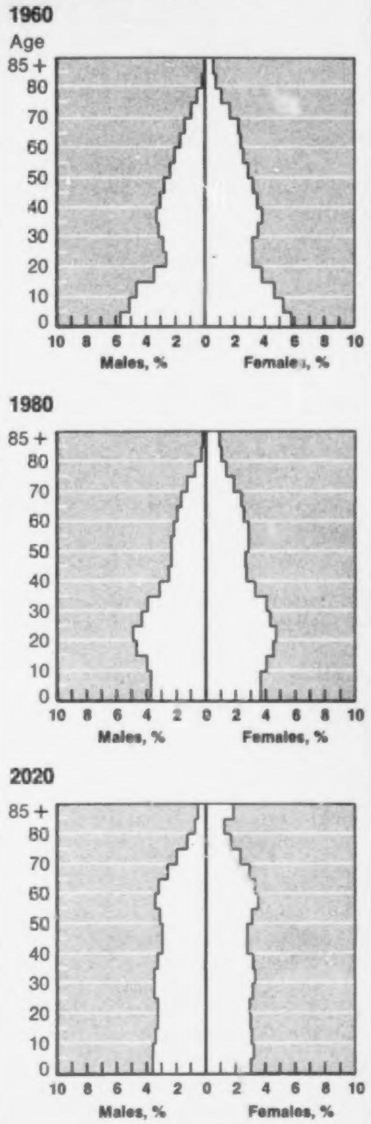
If the question of funding investments runs into the long term, what about pensions themselves? Although pensions in the chemical industry are sound today, what will they be like in 20 years? Or in 30 years? Pension-plan administrators claim no access to a crystal ball. At least one manager questions the wisdom of spending too much time worrying about variables no one can control or foresee—possible changes in the birthrate, for example, or a dramatic cure for cancer that raises the average life span.

Nevertheless, as the post-World War II baby crop matures, America is becoming grayer. Just earlier this month, for instance, the U.S. Census Bureau reported that the median age rose to 30.3 years in July 1981, up from 30 years in July 1980, and from 27.9 years in April 1970. During that 11-year span, the number of people in the 18-to-34 age group increased nearly 40%, to 69.4 million, and the 65-and-over group grew 13.4% to 26.3 million. On the other hand, the 5- to 13-year-old group declined 16.4%, to 36.7 million.

That sets up a basic conflict in the entire pension picture: the short-term attempts of companies to induce older workers to take early retirement, to cut payroll costs, and open career paths for younger workers, versus longer-range increasing costs to pension systems amid increasing concern about the soundness of the entire social security system. As the pool of workers funding social security shrinks, that will put more and more pressure on private pensions as a source of livable income.

Despite the options opened up by passage of age-discrimination laws, there is a clear trend among workers to retire earlier. Part of that is due to the liberalization of many large-

Age distribution will even out over next 40 years



Source: Towers, Perrin, Forster & Crosby

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Salary-reduction plans are gaining popularity

Either as a complement to company-sponsored pension programs, or as an option for companies with none, salary-reduction plans are the latest hot topic for employee-benefits managers. Final regulations are not yet out on such plans, but proposed regulations, issued last November by the Internal Revenue Service, have gained chemical companies' interest.

Under the proposed regulations, salary-reduction plans—also known as 401 (k) plans for the IRS code section of that number—enable an employee to divert some of his or her salary into a long-term savings program before it is taxed, up to 10% of pretax salary each year. Because the salary or wages are trimmed on a pretax basis, the income bracket is lowered and the employee pays lower income taxes. Meanwhile, other benefits—medical coverage, life insurance, and so on—are calculated on the basis of the total pretax income, thus the program has some benefits for the corporation, too. It pays social security tax on the new "reduced" salary or wages paid out, so it pays less.

The money is taxed eventually, of course. But when it is, either when the employee reaches the age of 59½ or when the employee must withdraw it for hardship purposes, the contributions withdrawn are eligible for a favorable 10-year averaging tax treatment.

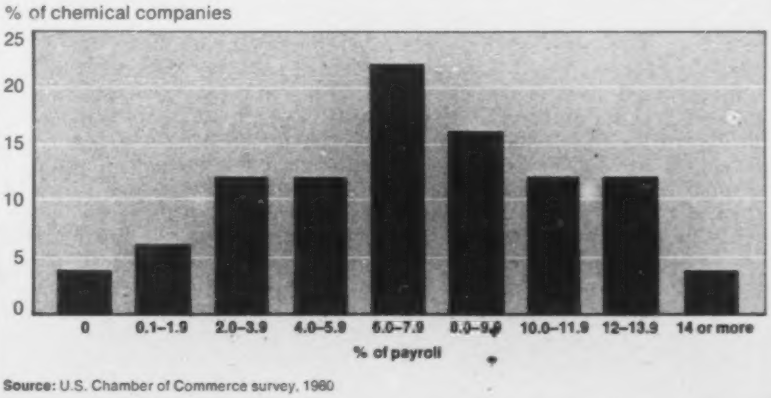
Ironically, such savings plans are being given more emphasis because of people's worries over the soundness of the social security system. But because taxable income is lowered, lower taxes also are paid—including lower social security taxes. So the widespread adoption of salary-reduction plans would mean a significant reduction in money put into social security, weakening that system even more.

company retirement plans, to give full retirement based on a "magic formula." Most frequently used is any combination of age and service equaling 85. Union Carbide, for example, adopted a rule of 85 in 1976, adding it as an alternative to the previous criteria of 62 years of age and 10 years of service, 60 and 30, or 65 years of age. Since then, the company says, its average retirement age has declined, and only 0.1% of its employees are older than 65.

By and large, when employees choose to work past the age of 65, they do so because of fears of inflation and because of concerns about social security. Then the question becomes whether the company continues to credit the years worked for calculating retirement benefits—and probably half of all companies don't. Some companies use the post-65 benefit freeze as a de-facto means to encourage retirement at age 65. But as the baby-boom cohort moves through the system toward retirement—or early retirement—that sort of thinking may have to change. The succeeding generation simply will not be large enough to fulfill workplace demands.

Companies with generous early-retirement programs may lose employees who set off for second careers, or even for second jobs with competitors. An employee aged 55, for example, could embark on a second career and be fully vested in a second pension by age 70. Companies may have to drop early-retirement programs to develop, instead, programs inducing older workers to stay on. These programs could include part-time employment of older workers, retraining of older workers, or adoption of the concept of phased-in retirement, suggest benefits consultants at Towers, Perrin, Forster & Crosby, of New York City, in a recent backgrounder on the implications of proposed social security changes.

Two thirds of chemical firms in survey paid more than 6% of payroll for pensions



Source: U.S. Chamber of Commerce survey, 1980

In fact, they add, industry well may see emerge a concept of highly subjective retirement ages, ranging from the late fifties to the early seventies. "If retirements become spread over such a wide range, it will become increasingly difficult to maintain a plan predicated on the majority of employees retiring at age 65," they point out.

That's in the future, however. For now, pension plan managers are concentrating on coping with present-day plan administration and regulations. No one suggests repeal of ERISA. There were abuses before its passage, pension planners agree, but ERISA has made contributions toward stabilizing pension planning. High on the wish list is the need to simplify, or streamline pension regulations, particularly paperwork.

Chamber of Commerce's Romig, for example, estimates that some 80% of all the reporting required of pension-plan managers could be eliminated. That would be especially so, he believes, if there were a single federal agency to regulate employee benefits. "We'd have a lot less, but more coherent, regulation imposed on us," he suggests—albeit at the risk of an all-powerful superagency.

One employee-benefits attorney suggests that reducing the number of "parties of interest"—people or companies a pension fund can't invest in because of possible conflict of interest—would simplify things, especially for large companies buying from a host of suppliers, selling to a host of markets, and so on. "If our company pension plan invested in a hotel, we employees couldn't even stay there," he grumbles.

Among the wishes least likely to be fulfilled is that the federal government become subject to all employee benefit laws that have been imposed on the private sector, including social security. If this wish actually came about, says one human-resources manager, "We'd have a much more understanding Congress and federal bureaucracy." □

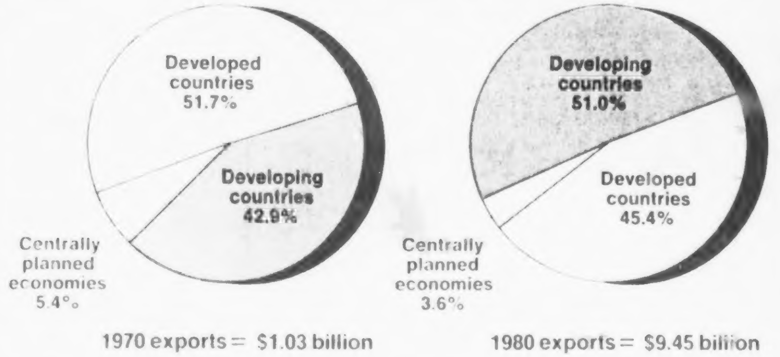
Developing nations boost chemical exports

With chemical exports rising faster than in industrialized countries, developing nations are destined to play bigger role in international trade

Earl V. Anderson
C&EN, New York

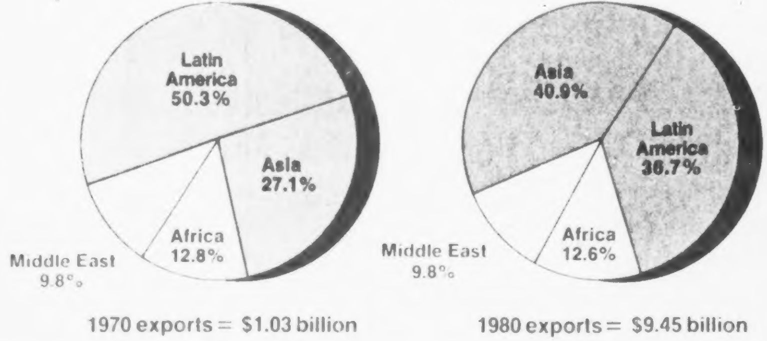
Developing countries are own best export customers

Chemical exports of developing countries to . . .



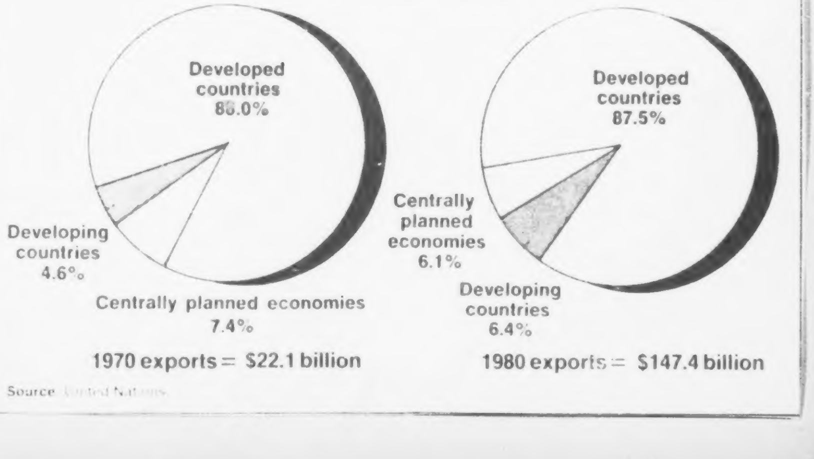
Latin America, Asia are leading chemical exporters

Chemical exports of developing countries from . . .



Developing countries increase share of world exports

World chemical exports



Source: United Nations

During the 1970s, chemical exports from developing countries grew faster than those from industrialized nations. As a result, the developing areas of the world were able to increase their share of world chemical exports 39%.

That may come as little consolation to many developing countries, especially the poorer, oil-importing nations that still are suffering increasing current account deficits as a result of high oil-import bills. But the fact that developing countries were able to outperform the major, industrialized countries in chemical exports during the seventies underscores the increasingly important role that the so-called Third World has played in international chemical trade. And it also hints at the still bigger role that these countries are destined to play as the 1980s unfold.

According to a recent analysis of world trade for 1970–80 compiled by the United Nations, world chemical trade (measured as exports) grew more than sixfold in that time span, from $22 billion to more than $147 billion. On both a volume and value basis, the major industrialized countries—in Europe, the U.S., and Japan especially—accounted for the bulk of the increase. And even in 1980, these countries maintained an overwhelming share, 87.5%, of world chemical trade.

But during the seventies, chemical exports from developing countries grew at an average annual rate of 24.8% per year, faster than those from the industrialized countries. By 1980, their combined chemical exports had reached a value of $9.5 billion, raising their share of world chemical trade to 6.4%, from 4.6% in 1970.

The growth in developing

Europe is the largest industrialized importer of chemicals from developing countries

Destination	Developing countries' chemical exports to developed countries $ Millions	Per cent	$ Millions	Per cent	Average annual growth, %
Europe	$262	50.4%	$1754	41.8%	20.9%
Republic of South Africa	6	1.2	35	0.8	19.3
Canada	3	0.6	36	0.9	28.2
U.S.	148	28.5	1049	25.0	21.6
Japan	66	12.7	1104	26.3	32.4
Australia/New Zealand	35	6.7	215	5.1	19.9
TOTAL	$522	100.0%	$4193	100.0%	23.2%

Source: United Nations

Asia tops developing areas as importer of developing country chemicals

Destination	Developing countries' chemical exports to developing areas $ Millions	Per cent	$ Millions	Per cent	Average annual growth, %
Africa	$ 39	9.0%	$ 334	7.1%	23.9%
Latin America	171	39.6	1479	31.4	24.1
Middle East	35	8.1	623	13.2	33.4
Asia	185	42.8	2264	48.0	28.5
Oceania	2	0.5	12	0.3	19.6
TOTAL	$433	100.0%	$4713	100.0%	27.0%

Source: United Nations

countries' share of chemical exports came primarily at the expense of communist nations, or centrally planned economies, as the UN calls them. Chemical exports in these countries grew more slowly than those of any other area of the world during the seventies. As a result, their share of total chemical exports slipped to only 6.0% in 1980 from 7.4% in 1970.

Among the developing areas of the world as defined by the UN, Asia has emerged as the leading chemical-exporting area. Between 1970 and 1980, Asia's chemical exports grew an impressive 30% per year, reaching $3.9 billion, or almost 41% of all chemical exports from developing countries.

One reason for Asia's success in chemical trade is that the continent contains four of the so-called "newly industrialized countries." The Republic of Korea and Taiwan both boast substantial chemical industries and, along with Singapore and Hong Kong, accounted for 53% of developing Asia's chemical exports in 1980. Japan and developing Asia itself are the major markets for these products.

Latin American developing countries' share of chemical exports from the entire developing world, meanwhile, fell to 36.7% in 1980 from 50% in 1970. The decline in chemical export share, however, is more the result of Asia's impressive performance than it is a poor showing on the part of developing countries in Latin America.

Chemical exports from developing

Much of Latin America's chemical exports stay within the region

Destination	Latin America's chemical exports $ Millions	Per cent	$ Millions	Per cent	Average annual growth, %
Developed countries	$325	100.0%	$1864	100.0%	19.1%
Europe	160	49.3	791	42.5	17.3
South Africa	3	1.0	28	1.5	25.0
Canada	3	1.0	21	1.1	21.5
U.S.	127	39.2	838	45.0	20.8
Japan	14	4.3	138	7.4	25.7
Australia/New Zealand	17	5.2	47	2.5	10.7
Developing countries	$176	100.0%	$1545	100.0%	24.3%
Africa	2	1.1	61	3.9	40.7
Latin America	166	94.8	1310	84.8	22.9
Middle East	1	0.7	122	8.0	61.5
Asia	6	3.4	50	3.2	23.6
Oceania	0	0	2	0.1	—
Centrally planned economies	$ 13	100.0%	$ 40	100.0%	11.9%
Asia	6	46.2	9	22.5	4.2
U.S.S.R.	0	0	11	27.5	—
Other Europe	7	53.8	20	50.0	11.1
Developed countries	$325	63.3%	$1864	54.0%	19.1%
Developing countries	$176	34.2%	$1545	44.8%	24.3%
Centrally planned economies	$ 13	2.5%	$ 40	1.2%	11.9%
TOTAL	$515	100.0%	$3470[a]	100.0%	21.0%

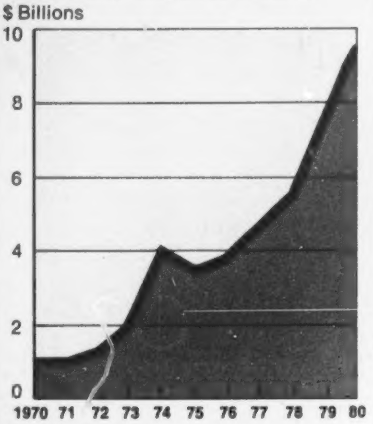
[a] Figures do not add because of UN statistical procedures. **Source:** United Nations

Japan is big importer of developing Asia's chemicals

Destination	Developing Asia's chemical exports $ Millions	Per cent	$ Millions	Per cent	Average annual growth, %
Developed countries	$ 82	100.0%	$1556	100.0%	34.2%
Europe	20	24.2	208	13.4	26.4
South Africa	1	1.2	6	0.4	19.6
Canada	1	1.2	14	0.9	30.2
U.S.	14	17.1	200	12.9	30.5
Japan	38	45.3	960	61.7	38.1
Australia/New Zealand	8	9.8	167	10.7	35.5
Developing countries	$186	100.0%	$2027	100.0%	27.0%
Africa	14	7.6	111	5.5	23.0
Latin America	2	1.1	21	1.0	26.5
Middle East	8	4.3	164	8.1	35.3
Asia	160	86.5	1722	85.0	26.8
Oceania	1	0.5	9	0.4	24.6
Centrally planned economies	$ 9	100.0%	$ 106	100.0%	28.0%
Asia	0	0	81	76.4	—
U.S.S.R.	7	77.8	22	20.8	12.1
Other Europe	2	22.2	3	2.8	4.2
Developed countries	$ 82	29.6%	$1556	42.3%	34.2%
Developing countries	$186	67.2%	$2027	54.8%	27.0%
Centrally planned economies	$ 9	3.2%	$ 106	2.9%	28.0%
TOTAL	$278	100.0%	$3869[a]	100.0%	30.1%

[a] Figures do not add because of UN statistical procedures. **Source:** United Nations

Developing countries' chemical exports rising



Source: United Nations

Latin American countries, in fact, grew an impressive 21% per year during the 1970s, hitting almost $3.5 billion in 1980. Brazil and Mexico also rank among the leading newly industrialized countries, and, together, these two nations exported more than 40% of 1980's total chemical exports from Latin American developing countries.

Argentina and Venezuela, of course, are other leading chemical exporters in the area.

More surprising is Trinidad and Tobago, which chipped in with $110 million in chemical exports in 1980.

Where chemical exports go is as important as where they come from. And, based on the UN analysis, it's obvious that the developing nations themselves are becoming their own best customers—at least as far as chemical trade is concerned.

The industrialized countries of the western world still are important customers for developing countries' chemicals, but not so important as they used to be. In 1970, they bought more than half the chemical exports from developing countries; by 1980, that share had dropped to 45%.

Meanwhile, the volume of chemical trade that remained with developing areas increased to $4.7 billion in 1980 from $433 million in 1970. That's a hefty 51% of the total.

As an outlet for chemicals from the developing world, the record of centrally planned economies is much less impressive. Their imports from developing countries increased only 20% per year, almost five percentage points below the world average. And their share of the total dropped to a meager 3.6% in 1980 from 5.4% in 1970. □

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CIRCLE 42 ON READER SERVICE CARD

Chemical & Engineering NEWS

Thermosets market is still plunging
A Key Polymers Review
Page 8

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METAL CLUSTERS

A perspective on their structure and diversity
Page 28

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Chemical & Engineering NEWS

Cover: Rhodium atoms in the metal carbonyl cluster ion $Rh_{22}(CO)_{37}^{4-}$ form a highly symmetric framework; colors depict various layers of rhodium atoms

2 Letters

Concentrates
7 Business
13 Government
22 Science/Technology

The Departments
44 Meetings
50 People
51 Awards
60 Newscripts

News of the Week

- ***Employment in the chemical industry**, including that of chemists, is dropping as the economy stagnates; layoffs and early retirement programs are increasing.* **Page 4**
- ***Refiners will be allowed to add** only 1 g of lead per gal to gasoline under Environmental Protection Agency ruling.* **Page 5**
- ***Rubber in scrap tires will be reclaimed cryogenically** using a process developed by Air Products & Chemicals.* **Page 5**
- ***New thermoplastic rubber** developed by Uniroyal is company's entry into competition to replace neoprene in insulation.* **Page 5**
- ***Exxon Donor Solvent process** to convert coal into synthetic liquid fuels completes successful pilot demonstration.* **Page 6**
- ***Cities Service agrees** to become wholly owned subsidiary of Occidental Petroleum after original tender offer is boosted to about $53 per share.* **Page 6**

Business

- ***Makers of thermoset resins hit hard** by the recession; dependence of phenolics, polyesters, epoxies on auto and construction industries slows sales.* **Page 8**

Government

- ***House bill sets up council on critical materials** to advise President on policy issues, review and coordinate federal R&D to ensure adequate U.S. materials supply.* **Page 14**

Science Policy

- ***Thomas F. Malone**, former foreign secretary of NAS, discusses science and human rights, global scientific scene.* **Page 15**

Science

- ***Techniques** in mass and NMR spectroscopy, chromatography applied to life sciences explored at FDA symposium.* **Page 23**

Education

- ***Applications of chemistry** stressed over theory, high school chemistry highlighted at biennial education conference.* **Page 25**

Special Report

***Study of metal clusters**—bridge between atoms in molecules and those in more extended arrays—has grown considerably since boron research of 1950s.* **Page 28**

ACS News

- ***A record 10,000 new members** joined the society this year, bringing total membership above the 125,000 mark.* **Page 42**
- ***Analytical Chemistry Division** again sponsors summer intern program.* **Page 42**
- ***ACS honors winners** of international science fair; high school students from Korea, Taiwan, U.S. take top prizes.* **Page 42**

Thermoset resins hit hard by sagging economy

Renewed drop in demand for durable goods has translated into increased sales losses for phenolic, unsaturated polyester, epoxy producers

Stephen C. Stinson
C&EN, New York

The major thermosetting resins—epoxy, phenolic, and unsaturated polyester—are headed toward the depths of the second trough of the current double-dip recession. Tied as they are to highly cyclical durable goods markets and the construction and auto industries, these resins have had to suffer through two attempts to bring inflation under control in a way that many other products and industries managed to avoid.

Hardest hit are phenolics, 87% of whose volume goes for bonding and adhesives in such products as laminates, insulation, plywood and fiber board, foundry molds, and rubber. Phenolics sales in 1982 may be half the all-time high of 1.74 billion lb in 1979. Polyesters, three quarters of which go into construction, transportation, and boats, fared a little better. After a loss of 25% from a record 1.25 billion lb per year set in mid-1979, polyesters made a partial recovery after mid-1981. Renewed losses may result in 1982 polyester sales that are 30% below those in 1979.

Epoxies always are an exception among the major thermosets. Their broad applications base and high-performance character make them relatively resistant to economic cycles. Epoxies continue selling strongly well into every recession. They command relatively high prices and profits throughout. Epoxies have a vigorous export market. Their only disadvantage is that the high-technology markets where they find use usually rise late in an economic recovery. Epoxies hit a record 337 million lb-per-year sales level after the beginning of 1980, lost only 7% of this by the end of that year in the first downturn, then went on to hit a new high of 340 million lb per year before the end of 1981. This year epoxy sales will be down, but for 1982, losses in this second slump may be limited to less than 10%.

Key Polymers

The reason for the strange behavior of thermosetting resins lies in the nature of the economic climate of the past three years. High rates of inflation and interest in that time sharply increased the prices of durable goods and of the loans needed to buy them. These factors had a heavier impact on such industries as construction, autos, and boats, where thermosets find most of their uses, than on other industries.

Inflation rose to 11% in 1979, with a spurt to 18% in the second quarter, hovered between 12 and 15% during 1980, then slowly subsided to present levels of 6%. Interest rates also took off in mid-1979. The prime rate, the rate banks normally charge their most favored customers, rose to 11% then, peaked at 20% in the spring of 1980, subsided to 11% that summer, then rose in excursions above 20% that lasted through the end of 1981. Falloffs in the prime rate have been steep this month, and at press time the rate was 13%.

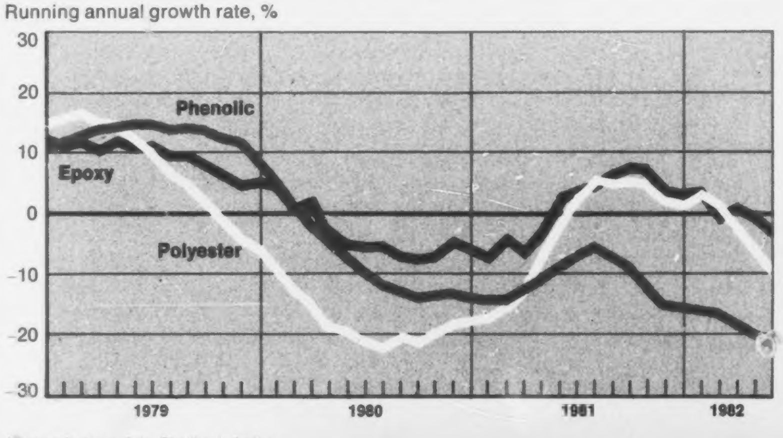
Thermosetting resins benefited from a temporary rise in business confidence and consumer spending in the first part of 1981. People thought that the coming tax cut and military spending increases would stimulate the economy, that decreased government spending would bring down inflation, and that lower inflation would deflate interest rates. These hopes evaporated over the summer.

A tight money policy of the Federal Reserve System combined with business demand for credit to keep interest rates up. Expectations that lower tax revenues from lower incomes and profits would raise the federal deficit also served to keep interest rates at high levels, because investors expected the government to increase its own borrowing. Auto sales resumed their slump with the end of rebates by car manufacturers.

Thus, total sales of the three largest-volume thermosets have been careening down hill for the past two years, with a pause for rest in the middle.

Thermoset resins are unlikely to recover truly from this most recent downturn until the beginning of 1984. This is because this new phase of the recession is a broader, more deeply set one, from which recovery cannot begin until sometime in 1983. The history of thermosets is that they have a flat year after the end of a recession. Unemployment was about

Thermosets suffer double-dip recession



Source: Society of the Plastics Industry

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5.5% in 1979 and rose above 7.5% in 1980 during the first downturn. Now unemployment is almost 10% as the recession has spread from construction and durable goods, through the industries that serve them, to other parts of the economy.

There is still a rough road ahead. Interest rates have declined to 13%, but this is still too high. Rates have come down this far, this fast, because of reduced business investment and demand for consumer credit, and because of expectations that Congress and the Reagan Administration can minimize federal deficits. If these latter expectations are not fulfilled, rates may rise again. The tax hike needed to trim deficits will not stimulate the economy. A key figure to watch in estimating the fortunes of thermoset resins is autumn sales of 1983 model cars.

Domestic sales of new U.S.-produced autos—a big user of thermosets—were down 8% to 8.4 million autos in 1979. Sales lost another 24% to 6.4 million in 1980, followed by a 3% fall to 6.2 million in 1981. Imported car sales have been about 25% of total U.S. sales in this period. The bright spot for thermoset resins in these three years of declining auto sales is that car makers have increased their use of plastics per car steadily. The largest gainer may be unsaturated polyester, which will go into increasing numbers of exterior body parts in efforts to reduce vehicle weight and improve gas mileage. Epoxy coatings could find increased use to avert corrosion as car makers try to attract buyers with improved warranties. Phenolics could lose some under-the-hood applications to thermoplastic polyesters.

C&EN converts, publishes phenolic sales data

In January 1981, the Society of the Plastics Industry Committee on Resin Statistics began reporting phenolic resin production and sales and captive use on a gross weight basis, which includes solvents. This change can cause confusion in following the continuity of fluctuations in these resins during a critical economic period. A simple conversion factor is unavailable, because phenolic resin products range from 42% resin content in insulation compounds to 100% for many friction materials, and because sales of various products have changed at different rates.

Based on consultation with industry experts, C&EN has estimated conversion factors for individual product types and applied these factors to SPI data to calculate sales and captive use on an actual resin basis for the six quarters since the reporting change. Because SPI always has reported molding compounds on a gross weight basis, including fillers, C&EN has used these figures without change for sales and captive use. To estimate production, C&EN has followed its own format since the key thermosets series began by subtracting an estimate for molding compound fillers. Conversion factors are thought to be accurate to two significant figures, so sales volumes may be accurate only to the nearest 100,000 lb. Nevertheless, C&EN has retained all figures in case these are of interest.

With the availability of consistent sales data, C&EN has resumed publication of running 12-month growth rates for phenolic resins. This curve shows that rate of sales decline bottomed out in February 1981, began a weak rally that peaked in August 1981, and resumed an accelerated fall that continues to the present time.

For the future, use of thermosetting resins in autos could rise if more foreign auto makers decide to begin production in the U.S. But there is a competing trend as U.S. car manufacturers make agreements with Japanese producers to import 300,000 to 400,000 per year of subcompact cars that have been designed and built overseas, beginning in 1984. Auto imports, whether by U.S. or foreign companies, represent sales lost by U.S. thermoset resin producers.

In construction, another big thermoset resin outlet, housing starts fell 14% in 1979 to 1.75 million, followed by further losses of 25% in 1980 to 1.31 million and 16% in 1981 to 1.10 million. Though the prime interest rate is down, fixed-rate mortgages are still above 17%, which may keep building of single-family dwellings depressed. Housing starts have hovered at an annual rate of 1.1 million this year because of building starts of federally subsidized housing. □

Phenolic sales fell 15% in 1981, and seem headed for further losses this year

	1981					1982	
Thousands of lb[a]	1st qtr	2nd qtr	3rd qtr	4th qtr	Total	1st qtr	2 qtr
Molding compounds[b]	71,162	68,081	59,073	50,581	248,897	48,940	46,539
Bonding & adhesive resins	249,340	256,886	250,809	215,447	972,482	201,332	216,698
Laminates	24,183	21,987	20,298	17,959	84,427	20,236	20,914
Coated, bonded abrasives	5,596	6,845	6,419	5,881	24,741	5,738	4,505
Friction materials	7,926	7,022	7,594	6,908	29,450	6,697	6,958
Insulation materials	35,693	37,226	42,283	36,722	151,924	33,113	33,828
Foundry resins	15,259	13,677	13,066	13,800	55,802	12,399	11,036
Plywood	121,158	132,071	123,837	100,408	477,474	95,718	108,389
Fibrous, granulated wood	25,951	26,283	25,068	19,060	96,362	15,049	19,419
Rubber	3,221	3,536	3,943	3,514	14,214	3,509	3,354
Other	10,353	8,239	8,301	11,195	38,088	9,233	8,295
Protective coatings	5,650	5,743	4,945	4,777	21,115	4,081	3,312
Other[c]	7,780	7,392	7,477	4,264	26,913	3,666	3,894
Total U.S. sales and use	**333,932**	**338,102**	**322,304**	**275,069**	**1,269,407**	**258,019**	**270,443**
Exports	5,152	6,227	4,475	4,507	20,361	4,526	4,286
TOTAL	**339,084**	**344,329**	**326,779**	**279,576**	**1,289,768**	**262,545**	**274,729**

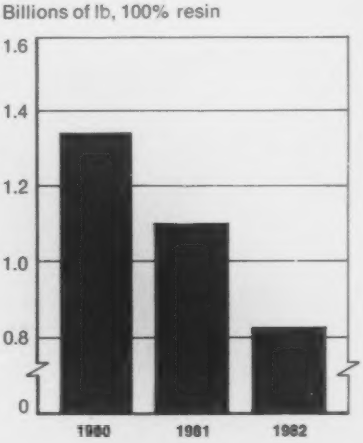
a Sales and captive use, 100% resin basis. b Reported on a gross weight basis in keeping with SPI tradition; molding compounds average 40% resin. c Includes nonadhesive uses in rubber production. **Sources:** Society of the Plastics Industry Committee on Resin Statistics as compiled by Ernst & Whinney, industry estimates

Key Polymers

Phenolics

- ***Markets plummeting***
- ***Real prices steady***
- ***Capacity excessive***

PRODUCTION



HOW MADE

Condensation of phenol and formaldehyde. One-stage resoles cured by heating; two-stage novolacs cured by heating with hexamethylenetetramine

MAJOR USES

Plywood 43%, insulation 14%, molding compounds 9%, fibrous and granulated wood 9%, laminates 8%, foundry core binders 5%

FOREIGN TRADE

Exports—2% of total sales, imports—negligible

PRICES

45 cents per lb, average, 100% resin basis

VALUE

$370 million for production, 1982

The recession has been crushing for phenolic resins, the worst off of major thermosets. Sales for 1982 will be down an estimated 44% from the peak year in 1979.

The continuing U.S. economic malaise is pushing phenolics sales in 1982 down 25% from 1981 to 970 million lb (actual resin). Total 1981 sales were 2.38 billion lb (gross weight) in 1981, according to a new reporting method by the Society of the Plastics Industry's Committee on Resin Statistics, whose statistics are compiled by accountants Ernst & Whinney. C&EN estimates that this represented 1.29 billion lb of actual resin, in terms of SPI's earlier mode of reporting.

Phenolics began to stumble after June 1979 as high interest and inflation rates crimped auto sales, construction, and general manufacturing. That month, running sales were increasing more than 15% per year. An ensuing slide continued until March 1981, when sales were falling at almost 14%. A following lesser rate of loss lasted only until August 1981, when it reached 5%. By June 1982, sales were falling at an even worse 21% yearly, with no letup in the accelerated pace. Phenolic resin sales in the 12-month period ended in June 1982 were 1.15 billion lb of actual resin, the lowest sales level in six years.

Chronically depressed sales have provoked no large-scale defections among resin producers, though a number of firms reportedly are reconsidering their position in the industry. A few small producers for captive use are said to have shut down permanently. Phenolics capacity thus remains excessive, according to industry observers, though it is impossible to estimate capacity even roughly. This is because of a large though unknown number of small producers.

About 87% of phenolics are used for adhesive and bonding applications in durable goods production, which is very susceptible to economic cycles. For example, plywood took perhaps 480 million lb of actual resin in 1981 but may use only 380 million lb this year. For laminates, the corresponding data are 85 million lb last year and perhaps only 77 million lb in 1982. In general manufacturing, including autos, 55 million lb of phenolics was used as foundry core binder for metal casting in 1981. This use may fall to 45 million lb in 1982. Fibrous and granulated wood, used mostly for furniture, took 96 million lb of phenolics last year but may need only 65 million lb in 1982. Insulation materials, such as binder for glass fiber thermal insulation, amounted to 152 million lb in 1981 and may reach only 140 million lb this year.

Insulation may be one bright spot after the end of the current hard times. Predicasts, a Cleveland-based marketing consultant firm, estimates that phenolic foam insulation boardstock sales may amount to more than 70 million lb in 1985 and 110 million lb in 1990. A few firms have begun to produce this 2 to 3 lb-per-cu-ft foam in the U.S. Raw materials costs are about 30 to 40% less than for the competing polystyrene and polyurethane foams it would chiefly replace. Insulating efficiencies are almost as great. Flame-spread rates and smoke densities for burning phenolic foam are said to be inherently less than for other plastic insulation foams, which must be formulated with fire-retardant chemicals to reach these levels. Uses are expected to be in roofing and in walls of new buildings, rather than reinsulating walls of existing buildings.

Molding compounds, another large outlet for phenolics, used 100 million lb of resin in 1981 to make 240 million lb of compounds. This application may take only 70 million lb of resin this year for 170 million lb of compound.

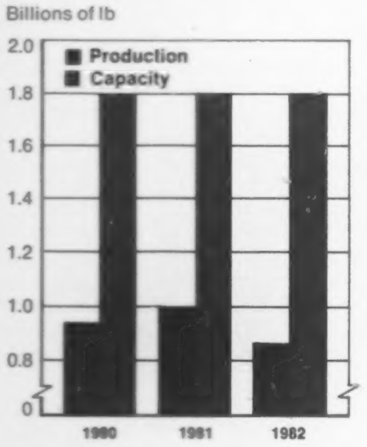
Though the next 12 months do not seem a promising time for new phenolic resin plants, new technology has been developed for production of free-flowing, uniformly colored and sized, granular resin. For example, Union Carbide has a suspension polymerization process for license that makes resin suitable for molding compounds, insulation binders and foam, foundry core binders, friction and abrasive materials, and waferboard. The process involves addition of a minute amount of a substance such as gum arabic to reactants to form a protective colloid. The colloidal suspension provides a limited number of nuclei around which polymerization can occur. The process avoids the dehydration, melting, pouring, solidifying, crushing, and grinding steps of conventional processes.

Key Polymers

Polyesters

- ***Markets falling off***
- ***Prices depressed***
- ***Capacity ample***

PRODUCTION/CAPACITY



HOW MADE

Mainly polyesterification of maleic and phthalic anhydrides with propylene glycol

MAJOR USES

Construction 31%, marine 17%, castings 12%, transportation 9%

FOREIGN TRADE

Exports—1% of total sales, imports—negligible

PRICES

60 cents per lb, average

VALUE

$520 million for production, 1982

Polyester's relative luck among thermosets in 1981 has run out in 1982. U.S. unsaturated polyester producers managed to finish 1981 with sales and captive use of 977 million lb of resin—no record, but still a 3% gain over the previous year. The renewed strength in resin markets that produced this gain already had begun to ebb in August 1981, and by July 1982 sales were falling at a 9% annual rate. The economic climate in end-use durable goods probably will worsen, and 1982 polyester sales may amount to just 870 million lb, the lowest level in six years.

It's these big-ticket end-use durable goods that can get polyester into trouble. For example, polyesters are buoyed up in good times and weighed down in bad by heavy involvement in boats and other marine uses. This market, which takes 17% of resin sales, represents discretionary spending for consumers, and so is very vulnerable to the present unemployment rate of 9.8%. Unlike automotive and construction areas, marine uses have been penetrated to saturation by these resins, so there is no cushion of increased market share to go for in times of lower boat sales. Moreover, marine parts average 65% resin, compared with only 35% in some construction laminates, so falling boat sales have a heightened impact on polyester volume. Marine sales accounted for 169 million lb of polyester in 1981, little changed from 1980, but 1982 sales could sink to 150 million lb.

Construction, another durables area, is the biggest unsaturated polyester market. Construction use of 301 million lb in 1981 was 31% of all polyester sales and rose 6% from 1980. However, for 1982, polyester sales in commercial, industrial, and housing construction might fall 14% to 260 million lb in 1982.

The transportation market is relatively small for polyesters and currently depressed, but this area offers promise for increased penetration. Auto trunk lids, hoods, and exterior body parts all are candidates. Transportation uses were up 12% in 1981 to 84 million lb, and outlets in autos, trucks, and buses spurted 18% to 65 million lb. But these gains could be wiped out in 1982 as the transportation market subsides 12% to 1980's level of 75 million lb.

Among uses for nonreinforced polyester, castings for such items as furniture and imitation marble for vanities sank 16% in 1981 to 119 million lb. The continuing poor outlook for durable goods could cause a further fall of 3% to 115 million lb in 1982.

Capacity is hard to estimate for unsaturated polyesters, so it is difficult to tell if there have been permanent reductions in the recent producer shuffle. There have been plant shutdowns, and some firms have sold all or part of their operations to other polyester producers. The same vessels used for unsaturated polyester production are convertible to make products such as alkyds for coatings, however. Industry observers tell C&EN that net polyester capacity has remained flat at about 1.8 billion lb for the past three years. To illustrate differences of opinion on this subject, two marketing analysis sources, SRI International and Predicasts, estimated 1980 capacity in separate studies at 1.7 billion lb and 2.1 billion lb, respectively.

Average price remains 60 cents per lb this year, with downward forces from increased competition matched by the opposite pull from some rising raw materials costs. Production of 100 lb of general-purpose polyester takes 43 lb of phthalic anhydride, 19 lb of maleic anhydride, and 38 lb of propylene glycol. Formulators add about 70 lb of styrene to this for cross-linking.

Polyester formulators are trying to hold the price line while still meeting customer needs by increasing the amount of less costly fillers and by foaming the polyester. One promising chemical blowing agent for thermosetting polyester foam is a sulfonylhydrazide, which is oxidized to nitrogen gas by excess peroxide initiator in the formulation. These efforts will tend to reduce the weight of actual resin in parts.

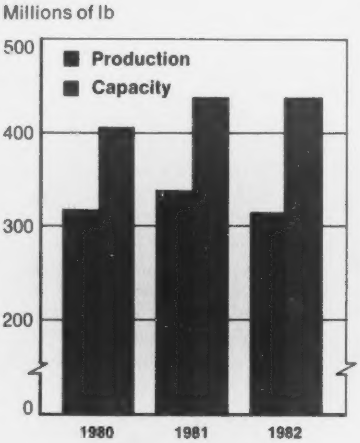
On the safety front, quiet concern is continuing about exposure of polyester fabricating workers to styrene vapors emitted by compounds. The Occupational Safety & Health Administration is staying with its exposure limit of 100 ppm in plant atmospheres, but is mulling a lower level. Industry has studies in progress seeking to demonstrate that a reduction to 50 ppm would produce no additional health benefits.

Key Polymers

Epoxies

- ***Prices up steadily***
- ***Demand soft***
- ***Capacity to expand***

PRODUCTION/CAPACITY



HOW MADE

Reaction of bisphenol A with epichlorohydrin followed by cross-linking with hardeners

MAJOR END USES

Coatings 47%, laminates and composites 22%, casting and molding 9%, flooring 7%, adhesives 6%

FOREIGN TRADE

Exports—12% of total sales, imports—negligible

PRICES

$1.25 per lb, average

VALUE

$317 million for total sales, 1982

The wide base of applications and high performance of epoxies make them more resistant to recession than other thermosets; but they are not immune, producers are learning once again this year as epoxy sales fall with other lagging sectors in the economy.

In 1981, total sales of epoxy resins were 332 million lb, 4.2% more than in 1980, helped along by a hefty increase in exports. Total 1982 sales may be only 310 million lb, however, a 7% drop, even in the face of continued strong exports.

Though calendar years are convenient benchmarks, 12-month running growth rates may better show the backing-and-filling pattern of epoxy sales in the past three years. After a long period of comfortable growth at about 13% per year in the late 1970s, epoxies began succumbing to recession in mid-1979. They reached their first bottom in October 1980, when sales were dropping at an annual rate of almost 7%. A temporary upturn stemmed losses for the year to 4% from 1979 levels, which peaked in October 1981 with an annual growth rate of 8.4%. Renewed sales falloffs limited 1981 sales gains to 4.2% over 1980. This new downturn produced annual sales loss rates of 3.3% by June 1982 and has not bottomed out yet. The end result of all the responses to the economy is that U.S. producers sold 320 million lb of epoxy resins in the 12 months ended June 1982—the same level as in mid-1979.

That the damage is not so bad as it could have been owes in part to a healthy export trade, which is growing not only in amount but as a proportion of total sales. The 31 million lb exported in 1979 was 10% of total sales and grew steadily to 41 million lb in 1981 for almost 12.5% of total sales. Exports for the first half of 1982 again are up sharply to an annual rate of 48 million lb. These high export rates may be due to one producer's decision that continuing advantages in raw materials prices justify concentrating its worldwide epoxy capacity in this country.

Capacity for basic liquid epoxy resin to support these total sales levels will remain adequate at 435 million lb per year among the three producers, Shell Chemical, Dow Chemical, and Ciba-Geigy, until mid-1984. At that time, Ciba-Geigy will bring on 100 million lb of capacity for this resin at McIntosh, Ala., and shut down 60 million lb at Toms River, N.J., for a net industry increase to 475 million lb.

The relatively healthy state of the epoxy business has enabled producers to increase prices steadily. The average price for unmodified resin was $1.05 per lb in 1980, according to the International Trade Commission, and may hit $1.20 per lb later this year. Resins subjected to some kind of advancement averaged $1.27 per lb in 1980, and may reach $1.45 per lb this year.

The largest outlet for epoxy resins is coatings, whose 137 million lb in 1981 was 47% of the U.S. market. Coatings applications may fall at least 12% to below 120 million lb in 1982. Uses for such coatings include industrial maintenance, marine parts, automobile undercoats, interiors of cans, and powder coating of appliances and outdoor metal furniture.

The second largest market is laminates and composites for such uses as electrical parts and electronic circuit boards. The 66 million lb that went for composites and laminates in 1981 amounted to 23% of U.S. sales. This amount may decline 9% to 60 million lb this year.

Epoxies for adhesives are divided between mature, slow-growing markets for general manufacturing and consumer repair kits and faster growing applications in specialty industries like aerospace. The 17.6 million lb used for bonding and adhesives in 1981 was 6% of sales, but only 16.5 million lb may be sold for these uses in 1982, down 6% from last year.

Commercial flooring accounted for 20.5 million lb of epoxy resins in 1981, or 7% of U.S. sales. Declines in construction and investment in new plants may bring these sales down 10% to 18.5 million lb this year.

Another outlet for epoxy resins is making molds for production of parts from other plastics in the auto and aerospace industries. These tooling resins, almost 30 million lb or 10% of sales last year, may amount to 25 million lb in 1982. This would be the greatest annual drop—17%—of the major epoxy uses.

Chemical & Engineering NEWS
September 6, 1982

9/8/82

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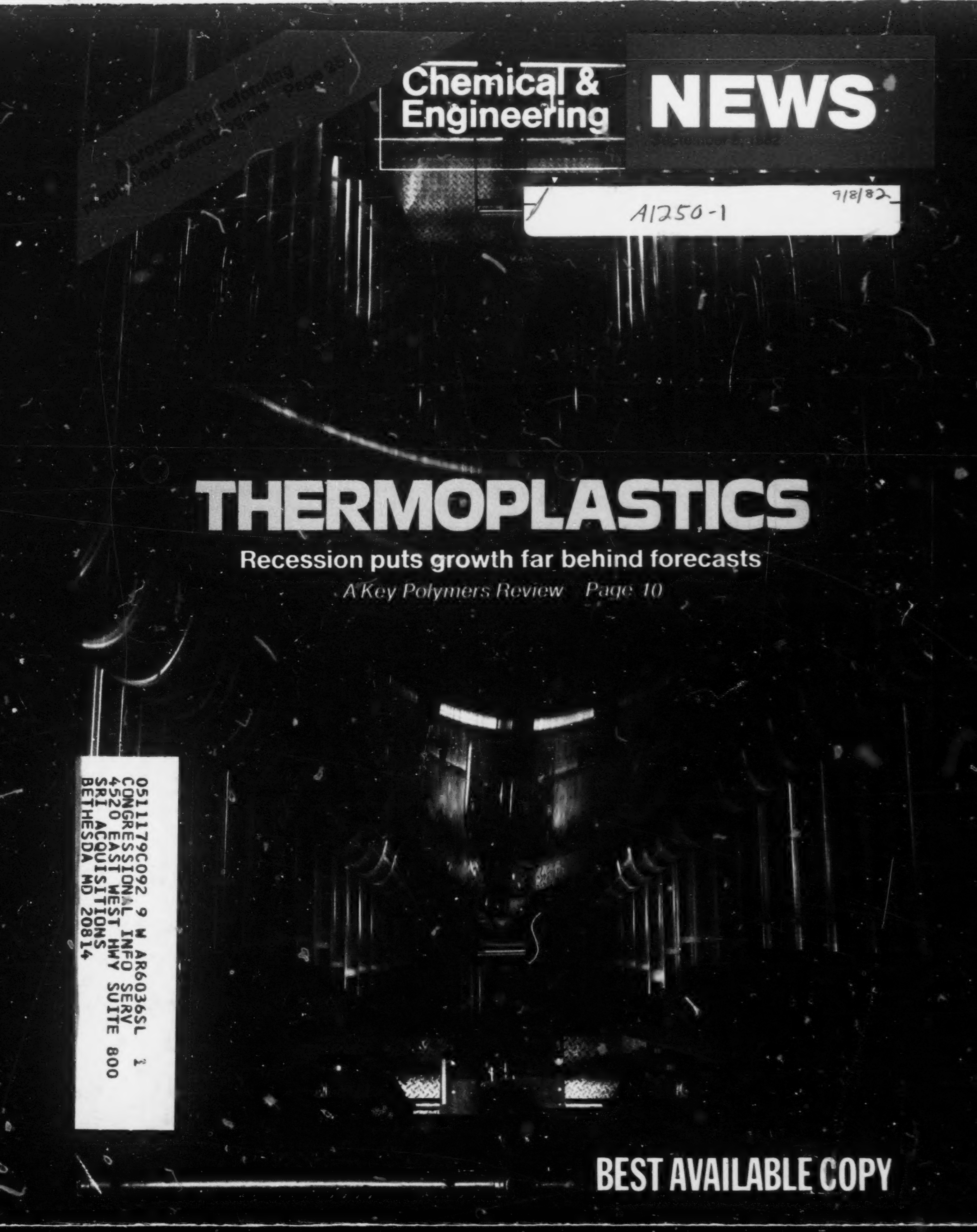
A proposal for reforming regulation of carcinogens Page 25



THERMOPLASTICS

Recession puts growth far behind forecasts

A Key Polymers Review Page 10

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Chemical & Engineering NEWS

Cover: A 90-inch-diameter, four-story-high bubble of polypropylene film at Hercules' Terre Haute, Ind., plant

2 Letters
3 Editor's Page

Concentrates

8 Business
17 Government
20 Science/Technology

The Departments

35 ACS Comment
48 Newscripts

News of the Week

- ***Environmental Protection Agency** gets agreement of 109 companies to pay for cleanup and groundwater testing at Chem-Dyne waste site in Ohio, one of country's most hazardous.* ***Page 4***
- ***World surplus of light hydrocarbons** in the 1980s will mean a further change in the pattern of feedstocks for making ethylene and other chemicals in steam crackers, Houston-based consultants predict.* ***Page 5***
- ***Capital spending** on new plants and equipment by chemicals and allied products companies during second-quarter 1982 fell 8.1% below that of the first quarter.* ***Page 5***
- ***The crunch of product liability suits** by asbestos workers that led to Manville Corp.'s bankruptcy filing causes concern in all chemical makers.* ***Page 5***
- ***A higher than normal incidence** of miscarriages and stillbirths was found among wives of workers in the wastewater treatment facility at Exxon's Baton Rouge refinery in company-commissioned study.* ***Page 6***

Business

- ***Thermoplastics suffer their third consecutive no-growth year;** high- and low-density polyethylene, polyvinyl chloride, polypropylene, and polystyrene's ills are worse than the industry's as a whole.* ***Page 10***

Government

- ***The seemingly never-ending battle of the budget** continues as Congress allocates more money to domestic programs at the expense of appropriations for the military requested by the President.* ***Page 18***

Technology

- ***Glassy metal alloys gain wide commercial use;** their magnetic properties are being exploited in new types of electrical devices, and their resistance to corrosion makes them good coatings.* ***Page 21***
- ***Biotechnology practitioners constitute large market** for sales of equipment and systems to carry out R&D and pilot development on products derived from genetic engineering or tissue-culture techniques.* ***Page 22***
- ***New fission counter,** 50 times more sensitive than conventional fission counters, was developed for a breeder reactor but has potentially important applications in monitoring and diagnostics.* ***Page 22***

Science Policy

- ***Increasing prevalence of cancer** has intensified social and scientific interest in its cause, but is today's policy of assessment and regulation of cancer-causing chemicals the best answer?* ***Page 25***

Thermoplastics continue long market sag

Pause in growth is in third year for high- and low-density polyethylene, polyvinyl chloride, polypropylene, polystyrene

Bruce F. Greek
C&EN, Houston

Though possibly an illusion from a sour year, the whole concept of time seems to have changed for U.S. plastics. A year ago, producers knew that their recovery from the 1980 recession had run into a snag (C&EN, Aug. 31, 1981, page 13). Now, pounded by another recession, they are wondering if their old models of growth and investment will ever resume.

So this is an eerie as well as painful period. Plastics never have had anything like it. After only one down year ever (1975) in their incredible history of growth, the dominant thermoplastics—low-density and high-density polyethylene, polyvinyl chloride, polypropylene, and polystyrene—are facing in 1983 the fourth straight year in a pause that began in 1980.

Needless to say, most of the industry's timetables from the late 1970s are out the window. Production, sales, prices, profits, plant use rates, exports, and most market development are hopelessly behind. Only in technology, where vigorous work continues on lower-cost processes, has the former pace held up.

Adjustment to the grim reality of the early 1980s has been forced and dreadful. Real-market prices have plummeted, many plants are shut down for the moment or permanently, and much new investment has gone on the shelf.

Key Polymers

Instead of outracing the rest of the chemical industry, as plastics did decade after decade, the five largest-volume thermoplastics are magnifying the industry's problems. Most plastics data are worse than for the industry as a whole.

Here's the 1982 scoreboard. Odd though it may seem, the five plastics' combined production of 24.3 billion lb this year will be 9% below 1979 output after a 5% drop from 1981. Average real-market prices have slumped 16% in 1982 to 31 cents a lb from 37 cents in 1981. In 1981, prices eked out a 3% increase from 1980.

The double wallop from volume and prices has produced a stunning setback for plastics' value this year. After a combined production value of \$8.7 billion in 1980 and \$9.5 billion in 1981, the five leading thermoplastics' value will fall 20% to \$7.6 billion in 1982. Compare this to an estimated 5% drop in 1982 sales for the basic chemical industry.

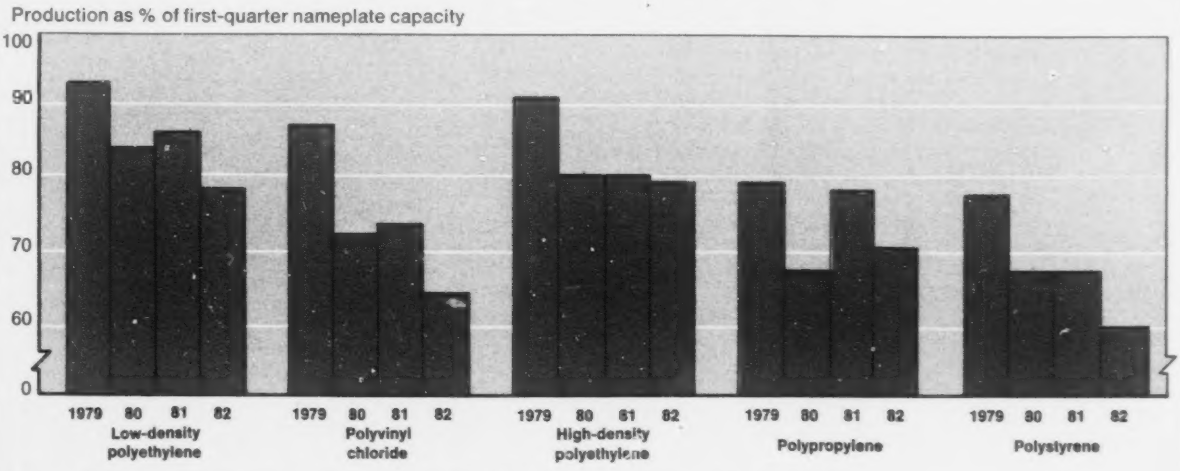
Unfortunately, although plastics markets sagged in 1982, plant capacity kept right on coming. Nameplate capacity in the first quarter was up 3% from 1981 to 34.2 billion lb. This total is up 11% from 1979.

The effect on capacity use levels is a foregone conclusion. Average capacity use rates for the five thermoplastics dropped from 86% in 1979 to 75% in 1980, 74% in 1981, and 71% this year.

This despite the beginnings of an inevitable capacity shakeout, now hitting low-density polyethylene, polyvinyl chloride, polypropylene, and polystyrene. In LDPE and PVC, shutdowns are being accelerated by a process-cost gap that has developed between newer and older plants. Vastly improved technology has created such a cost penalty for older plants that many more shutdowns are expected.

For the next year, hopes are growing for a good recovery. But

Plant use for five thermoplastics will drop across the board in 1982



Sources: Industry and C&EN estimates; Ernst & Whinney for the Society of Plastics Industry's Committee on Resin Statistics plastics' financial outlook still is shadowed by some ominous clouds. Because of low plant use rates, prices still are under downward pressure from customers.

On the other side of the production process, the cost of raw materials, a bargain up until now, may start rising again. So analysts believe that overall profitability in plastics—what little that does exist—may suffer through the rest of this year and even in 1983.

Many feedstock costs for plastics are beginning to rise as a result of recent large increases in costs of light hydrocarbons from natural gas. For example, ethane, at least on a spot price basis, now costs 50% more than it did four to five months ago. Propane costs a third more. Hence, derivative ethylene, now ranging from 17 to 19 cents a lb, could soon tack on 2 or 3 cents. Later on, this all-important starting material for four of the five major thermoplastics could go up even more, perhaps another 2 to 3 cents, analysts predict. Could thermoplastics producers pass through these cost increases? Not now, industry sources say. So profitability could dip some more before climbing in 1983 or later.

Unhappily for producers, they rather quickly passed on raw material cost breaks from earlier this year to customers, exacerbating the big declines in sales dollars. For example, list prices for LDPE's large-volume grades now are about 10 cents a lb below prices after discounts a year ago. Of course, ethylene at 17 cents a lb this spring was 10 cents below its old price.

These cuts, along with below-forecast production, have led to large declines in the commercial value for thermoplastics in 1982 from 1981. For example, LDPE, heavily buffeted by price cuts, in part the result of linear polyethylene's reaching the market and carving out its segment, will have commercial value of $2.0 billion in 1982. This is down 31% from a downward revised $2.9 billion for 1981. Other thermoplastics will have lesser declines in their commercial value in 1982.

Even in the best of times, relatively little of thermoplastics' commercial value actually goes into producers' pockets as profit. Most of the selling price goes for raw materials, plant operating expenses, and cost of the plant investment. When competition gets tougher as in the past year, some cost components such as raw materials and plant operating expenses are cut through efficiency improvement programs to cover discounts from list prices. But there is a limit to this, so eventually all of the discounting comes from profits.

When commercial values decline for long periods, producers eventually are forced to decide whether to stay in business. Such decisions well may be under way at various thermoplastics producers, and odds are that the answer will be yes in many cases. Prime candidates are smaller, older units in polystyrene, polyvinyl chloride, and conventional low-density polyethylene.

Pressing demand problems will be the main cause of shutdowns in polystyrene and PVC over the next few years. For LDPE, however, the main impetus will be the technology shift to linear low-density material, which is made in plants not too unlike HDPE units. Low-pressure operations inherently are lower-cost operations. This makes all high-pressure process units suspect at today's energy costs.

Technology also is available to shift both conventional high-density plants and high-pressure, low-density plants over to low-pressure operations to make either linear low-density polyethylene or high-density polyethylene. Hence, the two traditional types of polyethylene are tending to blur on plant source. In the next few years, individual sources of high- or low-density polyethylene will be difficult to ascertain. Capacity reporting could change to combined polyethylene data, and eventually the density distinction could end, much as have property distinctions among other polymers.

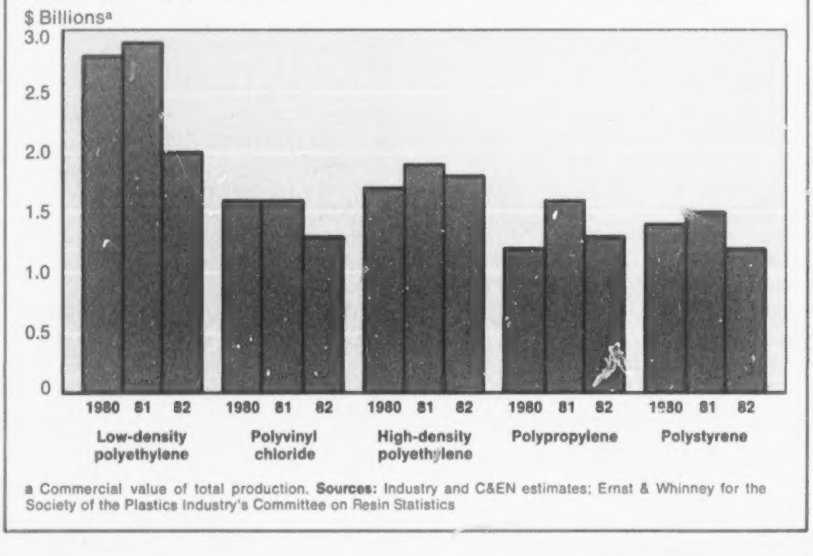
The changes in polyethylene production technology and product mix will take several years to complete. Some of those changes may be different from what is expected now as economics change. Financing those shifts won't be easy given expected profitability limits. But once the changes are made, some improvement in profitability is likely, even with slower growth rates expected for these major thermoplastics.

In the meantime, some curious flip-flops have occurred in value relationships among the thermoplastics themselves. These changes suggest changed competitive conditions in some markets. The most obvious is that polypropylene no longer is on the cheap end of the spectrum. It is the only one of the five whose real price has held up since 1980. In so doing, polypropylene is not far behind polystyrene and HDPE, which remain the most expensive. Polypropylene doesn't seem to have suffered so much as has polystrene, from its relatively high value. The polypropylene price remains high because raw material propylene prices have proved much stronger than ethylene prices and, in fact, have surpassed ethylene after many years on the light side.

The really inexpensive thermoplastics are LDPE and, especially, PVC. Both have had a price shock because of falling markets. The only saving is that raw material ethylene and chlorine have been extraordinarily cheap.

For details on the immediate 12-month outlook for the five thermoplastics, see the following pages.

Low-density polyethylene suffers the worst value drop



[a] Commercial value of total production. **Sources:** Industry and C&EN estimates; Ernst & Whinney for the Society of the Plastics Industry's Committee on Resin Statistics

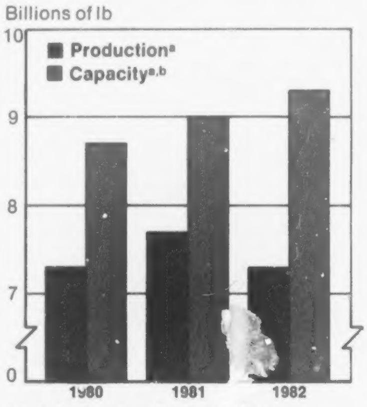
Key Polymers

$-\!\!\left[CH_2-CH_2\right]\!\!-_n$

Low-density polyethylene

- ***Demand down***
- ***Capacity still up***
- ***Price cuts deep***

PRODUCTION/CAPACITY



a Includes linear low-density polyethylene.
b First quarter.

HOW MADE

Polymerization of ethylene at high and low pressures aided by catalysts and initiators

MAJOR FABRICATED FORMS (U.S.)

Film, largely for packaging, 65%; injection molding 10%; coatings 10%

FOREIGN TRADE

Exports—may rise to 1.1 billion lb in 1982, imports—negligible

PRICES

Large-volume list prices way down, to 28 to 32 cents per lb; discounting still widespread

COMMERCIAL VALUE

$2 billion for production, 1982

A year ago, low-density polyethylene had the brightest fortune and certainly the most excitement among major thermoplastics. Its plant use and general recovery had kept up, and the dramatic technology shift to the linear low-density (low-pressure) product type promised another boom in new markets. Investment plans crowded the world production scene.

How things have changed! LDPE has had the most stunning financial reversal among thermoplastics in the intervening recession, and even the shift to the linear low-density product seems to have its problems. One result could be stepped-up closings of old plants or accelerated conversion of old capacity to new, low-pressure technology.

Even though linear LDPE is the current star of the thermoplastics business, its production will not much exceed 1 billion lb in 1982, or 15% of the LDPE total. Hence, as with many chemical and nonchemical products, the newest entry gets inordinate attention while earlier warhorses still carry the main load in production, sales, and profit.

Combined production of linear low-density product and conventional low-density polyethylene will be about 7.3 billion lb in 1982, down 5% from 1981. The 1982 output will about match that of 1980 and will be down 6% from the 1979 record of 7.8 billion lb.

Nameplate plant capacity for all kinds of low-density polyethylene was about 9.3 billion lb as the year opened. Since then, a number of switches have occurred. The largest decline was shutdown of Cities Service's plant at Lake Charles, La. Expansions have taken place exclusively in linear low-density capacity; these have more than offset the decline from shutdowns. Many of the expansions, however, have come well into the year, limiting actual production for 1982.

Estimates around the industry vary on capacity actually available for production this year. On balance, it likely will run about 9.7 billion lb. Some capacity will not run much during the year, and some shutdown capacity probably will never be restarted, even though no scrappage has been announced.

On the basis of an estimated average nameplate capacity of 9.7 billion lb this year and estimated production of 7.3 billion lb, the average operating rate for 1982 will be 75%. Production estimates for the year are within about 200 million lb of one another. This production uncertainty, plus the unusually choppy capacity picture, could change the final operating rate several percentage points.

By contrast, little change is due in the use pattern for low-density polyethylene in 1982. Exports of this plastic will increase 10 to 15% because of lower prices, helping to make up for declines in U.S. demand. Exports in the two previous years ran a bit less than 1 billion lb each.

Uses of low-density polyethylene in the U.S. long have been led by film, most of which goes into packaging of one kind or another. Film in packaging has become so widespread that polyethylene is becoming the mark against which competing materials are measured, much as paper was 25 years ago.

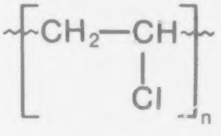
Into the all-important film domain now comes linear low-density polyethylene, which boasts significantly better strength. The initial effect, and one which continues apace, is downsizing film thickness without loss of strength. Downsizing seldom is directly proportional to the increase in film strength of linear low-density material because most films contain blends of linear low-density and conventional low-density polyethylene. The amount of downsizing also undoubtedly varies with the end use of the film. The net lower effect on sales for the two kinds of low-density polyethylene is difficult to estimate. Analysts estimate the dent between 10 and 30%.

Since production costs also are much lower for linear low-density polyethylene than for high-pressure-process material, the obvious result will be a continuing shakeout of old high-pressure process units. Some will be converted to linear low-density production, but others will be torn down.

The economy may have the final say on these capacity changes in low-density polyethylene. Given a mild recovery, it's possible that, despite the advantage of a hot new product form, low-density polyethylene might take as long as other thermoplastics to regain 1979 volume and start growing again—at least another year.

Key Polymers

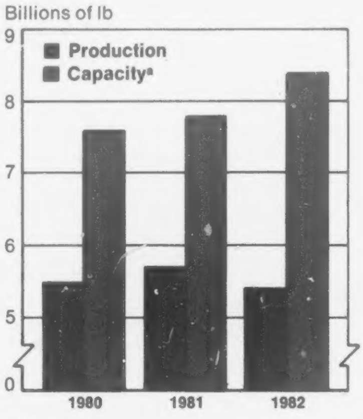
Polyvinyl chloride



$$\left[-CH_2-\underset{Cl}{\underset{|}{CH}}- \right]_n$$

- ***Demand falling***
- ***Capacity in shakeout***
- ***Prices shattered***

PRODUCTION/CAPACITY



[a] First quarter.

HOW MADE

Polymerization of vinyl chloride by suspension, emulsion, solution, or bulk processes, sometimes using initiators

MAJOR FABRICATED FORMS (U.S.)

Extrusions, nearly two thirds in pipe, 60%; calendered sheet and film 10%; coatings 5%; moldings 5%

FOREIGN TRADE

Exports—rising to more than 550 million lb in 1982, imports—negligible

PRICES

List prices from 32 cents for large volume to more than 50 cents for specialty grades; discounts about 25% for large volume

COMMERCIAL VALUE

$1.3 billion for production, 1982

Polyvinyl chloride's toughness—created by the stabilizing effect of chlorine on the common hydrocarbon backbone of the molecule—also can be its greatest problem in economic periods like the present. As a result, PVC is a crippled product with nothing but rough sailing ahead. It will be too rough for a lot of producers in this crowded field, and already they have started to leave. Shakeout is the key word for this business in 1982 and 1983.

The resin's toughness can be a benefit in good years, but this property ties the polymer—unlike the consumer-oriented polyethylenes—to heavy-duty markets, most notably construction pipe. These markets are, in turn, part of the big-ticket durables' corner of the economy. This is the sector that suffers most in periods of high interest rates and recessions, when customers run out of money.

So PVC is in severe trouble, just after a prosperous time in the late 1970s that drew a lot of new investment and better technology into the business. In the 1980s, many analysts believe that big-company investors still can win in PVC, but smaller, older producers will drop out.

For 1982, not even the optimists foresee improvement from 1981's depressed production of 5.7 billion lb. The predicted range this year, from 5.2 billion to 5.5 billion lb, will be as much as 900 million lb below the peak of 6.1 billion lb in 1979.

Three years of production below the old high point, coupled with dollops of new plant capacity at several large producers, have led to a round of plant closings this year. Fierce downward pressure on prices this spring could have been the last straw after continued low rates of plant use. Overall capacity dropped 500 million lb per year in the second quarter alone. These shutdowns, expected to be permanent by many industry sources, involve small plants with capacities of less than 200 million lb per year. In the first quarter, other capacity also came down.

The specter of overcapacity was clear well before 1982. It already had led to delays or cancellation of new plants for both polymer and associated monomer. These decisions took out another billion lb of potential PVC capacity, which was due in 1982 and 1983.

As third-quarter 1982 began, annual nameplate capacity for PVC plants dropped below 8 billion lb per year, perhaps to 7.8 billion lb. Hence, if production this year totals about 5.4 billion lb, the current plant operating rate will be a feeble 69% of capacity.

This low rate helped put the pressure on prices this spring and summer. It didn't do polymer producers much good that raw material ethylene and chlorine prices also came down. Any savings went mainly to polymer customers. For producers, other costs continued to rise, tightening the overall cost-price squeeze and leading to plant shutdowns.

A small recovery in demand currently is under way, but price firming has been minimal even though summer shutdowns have ended at downstream fabricating plants. If anything, polymer prices have been weaker than earlier in the year despite vigorous levitating efforts by producers. A rising trend in monomer prices is just making matters worse for polymer producers.

One area actually aided by PVC's weak prices is exports. For the year, exports could be up 10 to 20% to more than 500 million lb. This gain would add up to 100 million lb to the production total.

Other PVC outlets don't have much going for them because of the depressed economy. The biggest single use, pipe, continues to be buffeted by the slump in construction. This slump has led to large inventories at the pipe product level that will not be worked down until there is some turnaround in the economy. Other construction uses such as siding, window frames, and flooring also have been hurt, and their growth prospects have been delayed for another year.

Until home construction and related uses of this polymer recover, PVC will continue its wrenching shakeout. Output will not climb back fully until well beyond 1983, and financial health will be very much in the distance. PVC's real-market price is below the ethylene price of 18 months ago, having dropped about 20% from its 1980–81 plateau. The resin's total market value this year of about $1.3 billion also will be down about 20% from 1981.

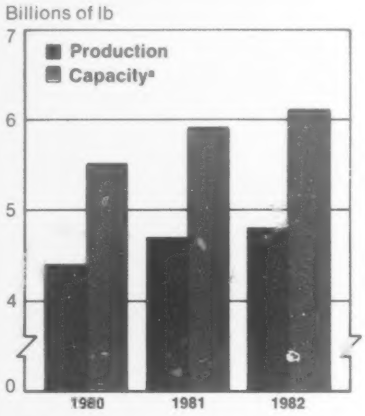
Key Polymers

High-density polyethylene

$-\!\!\left[\mathrm{CH_2{-}CH_2}\right]_n\!\!-$

- ***Demand inching up***
- ***Capacity also up***
- ***Price discounts heavy***

PRODUCTION/CAPACITY



[a] First quarter.

HOW MADE

Polymerization of ethylene catalyzed by metallic salts and alkyls

MAJOR FABRICATED FORMS (U.S.)

Blow molding, mainly containers, 40%; injection molding 25%; pipe and conduit 10%; film 5%

FOREIGN TRADE

Exports—rising to more than 600 million lb in 1982, imports—less than 100 million lb

PRICES

List prices 45 to more than 50 cents per lb; discounting heavy

COMMERCIAL VALUE

$1.8 billion for production, 1982

Once again, high-density polyethylene provides a happier note or two in thermoplastics' sad song this year. It has the highest plant use rate of the five, at 79% of nameplate capacity, and actually is inching up in production on the strength of rising exports.

HDPE still has problems. Its price is roundly discounted, leading to a value drop from 1981. And some markets, such as pipe, are reeling in the recession.

Still, other markets, especially the big one in packaging, are fairly stable and could grow again. This plastic is the stiffer polyethylene best known in consumer containers such as milk bottles.

In 1982, production of high-density polyethylene probably will reach 4.8 billion lb, up about 100 million lb from 1981. Although this level won't match the record 5.0 billion lb in 1979, it still will set the resin apart as the only major thermoplastic to gain in production this year.

There are pessimists in the business who expect output to decline a bit in 1982, perhaps 100 million lb from 1981. But even with such a 2% drop, HDPE would do better than the other thermoplastics, whose declines will range from 5 to 11%.

Estimates of HDPE production may be less accurate than in the past because of the development of linear low-density polyethylene technology. Some high-density material can be made in the new linear low-density units. Such volume can slightly skew production estimates for both high- and low-density polyethylene.

However, industry sources guess that the amount of HDPE produced in linear low-density units will be quite small in 1982—as little as 100 million lb. Hence, analysts' range of total production estimates for high-density of 4.6 billion to 4.8 billion lb should be reasonably close.

Excluding the secondary high-density capacity in linear low-density plants, nameplate plant capacity for high-density polyethylene was 6.1 million lb in first-quarter 1982. Addition last year by Phillips Petroleum was offset by shutdown at Cities Service. Some expansions still are under way, but others have been halted. Net additions in 1982 will be small, adding very little to production.

The resulting plant operating rate of 79% of capacity will be nearly the same as in 1981 and 1980. So, as one source puts it, this polymer isn't doing badly relative to other plastics or organic chemicals in general. And high-density has been a much needed mainstay for the ethylene market.

Exports are HDPE's main boost this year, since U.S. demand is not pulling up. Propelled by bargain prices, exports are returning to more than 600 million lb in 1982 after slumping to about 450 million lb in 1981.

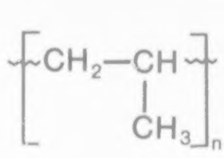
In the U.S., major uses are expected to vary no more than 5% up or down from volume in 1981. Containers, mainly bottles but also shopping bags, are the top market. Most containers with tight lids are blow-molded in a wide variety of shapes for a host of uses. Although capture of brand new markets seems mostly over, these outlets should continue to grow long-term at an above-average rate for this resin.

Injection-molded products from HDPE also have diverse shapes and uses. Nearly a third of these items by weight are containers with tight lids. Another sizable portion are auxiliaries such as cases for milk bottles. Growth in these areas has slowed because of relatively long product life, which makes replacement volume small. Other injection-molded products such as housewares and toys aren't likely to grow much, especially since competition is coming from polypropylene.

Pipe, tubing, and film account for many of the other uses of HDPE. Pipe has been hit by the slowdown in construction markets and by the poor agricultural economy, which is reducing expansion in end-use irrigation systems. Film used in shopping bags has had good growth but could run into strong competition from linear low-density polyethylene.

Largely because of its strength in such packaging uses, HDPE has escaped the financial nosedive hitting LDPE. High-density suffers price discounts, but its real-market price is down only a few cents a pound from 1981. Total value of high-density production is about $1.8 billion in 1982, down a bit from the peak of $1.9 billion in 1981.

Key Polymers

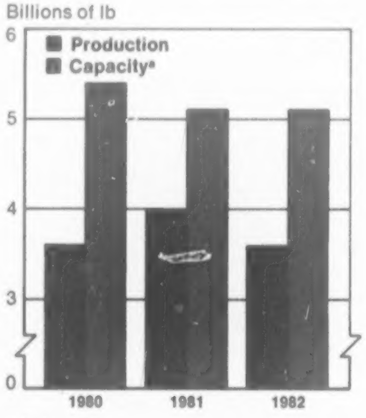


$$\left[-CH_2-\underset{\displaystyle CH_3}{\underset{|}{CH}}-\right]_n$$

Polypropylene

- ***Demand off***
- ***Capacity flat***
- ***Price discounts small***

PRODUCTION/CAPACITY



[a] First quarter.

HOW MADE

Polymerization of propylene catalyzed by metallic salts and alkyls

MAJOR FABRICATED FORMS (U.S.)

Injection molding 40%, fibers 35%, film 10%

FOREIGN TRADE

Exports—rising to 750 million lb in 1982, imports—negligible

PRICES

List prices 40 cents per lb for large volume; relatively small discounting

COMMERCIAL VALUE

$1.3 billion for production, 1982

Polypropylene has been eclipsed as the hotshot thermoplastic by the sensation from linear low-density polyethylene. But polypropylene still is the most versatile resin. It thrives on new market development and is the only one of the five largest-volume thermoplastics with a big stake in fibers. It also is proportionately the most international with 21% of U.S. output headed for export this year.

But polypropylene's diversity merely has exposed it to more recession-wracked markets this year, and volume will be down. Production in 1982 could be 3.6 billion lb, about the same in 1980 but down 10% from its record 4.0 billion lb in 1981.

The resin could do better than this. Some industry sources predict 3.8 billion lb production, citing substantially increased exports. They expect this important outlet to climb perhaps 100 million lb from 1981 to 750 million lb. They also foresee a recovery in automotive uses and continued growth in packaging, especially rigid forms.

Current polypropylene nameplate plant capacity totals about 5.1 billion lb per year. If production in 1982 reaches just 3.6 billion lb, the average plant operating rate will be 71% of capacity. For the higher production estimate, the operating rate would go to 75%.

Capacity appears at first to be stable because there have been no reports of expansion for well over a year. However, capacity still could be growing, since catalysts and other technology continue to improve. Although such additions are hard to divine and have varying success, some industry sources say they will be small this year, perhaps 50 million lb, owing to the profit squeeze.

Normally, less-than-robust business would appear to be an incentive to develop new products or improve existing ones to spur sales. Some of this undoubtedly is going on. But offsetting this is the conservatism of downstream fabricators. Faced with difficult times, including high inventory costs, they are reluctant to change to a new polymer that might perform differently from an older, more familiar material. So unfortunately, innovation can be rarer in these times than otherwise, says one polypropylene executive.

Competition among polymers hasn't hurt polypropylene very much even though it has a real selling price about 10 cents a pound higher than most low-density polyethylene and about equal to high-density polyethylene. Polypropylene's relative price rise is due to a corresponding rise in the relative cost of raw material propylene. After trailing ethylene by a few cents a pound in past years, propylene now leads by a few cents.

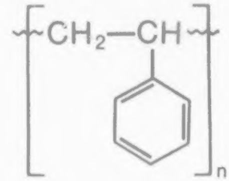
U.S. demand for polypropylene is down, mostly for the usual recessionary reasons. For example, use in the important transportation area is down because of the slump in car production. Use of polypropylene per vehicle probably is holding its own because of increased applications. However, downsizing in cars tends to reduce the size of an individual piece, and total auto output is way off. Similarly, appliance uses are down because production has fallen.

Fiber and filament uses have fallen because of the crunch in home building and home furnishings. Polypropylene volume in carpets and furniture is down about as much as in injection molding. High hopes for growth of fibers in apparel are yet to be realized. Fashion seems to have more influence in this than do the good physical properties of polypropylene fibers. Nonwoven products of polypropylene fibers have moved beyond the experimental stage but many of their developmental and performance questions still are unanswered.

Film, particularly the oriented types, has one of the better records this year among polypropylene markets. For example, its cost-performance characteristics have allowed it to replace cellophane in many packaging uses. Still, problems of heat sealing and oxygen penetration—not unsolvable but expensive to handle—tend to hold back growth. Nonoriented film continues to be offered, but future sales growth appears slow compared to its faster-moving cousin.

Despite this immense market spectrum, including many potential future growth areas, polypropylene has stalled in 1982. Although not in a tailspin like polyvinyl chloride, polypropylene needs a fresh expansion in the economy to reach the new records its vigorous developers expect.

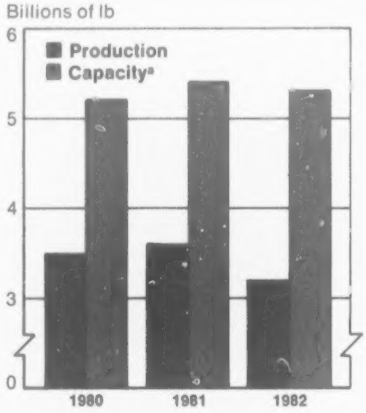
Key Polymers



Polystyrene

- ***Demand sliding***
- ***Capacity shaved***
- ***Price discounts heavy***

PRODUCTION/CAPACITY



[a] First quarter.

HOW MADE

Polymerization of styrene using a peroxide initiator

MAJOR FABRICATED FORMS (U.S.)

Injection molding 50%, extrusions 35%, expandable beads 10%; one third of end markets in packaging

FOREIGN TRADE

Exports—holding at about 125 million lb in 1982, imports—negligible

PRICES

List prices 45 cents per lb and up for large volume; discounting heavy

COMMERCIAL

$1.2 billion for production, 1982

The center of gloom for thermoplastics, as usual, is the main aromatic, polystyrene. At the top in price and the bottom in market performance in 1982, this resin can't seem to win. Even with some growth coming in a reinvigorated economy, polystyrene faces a hard haul over the next decade.

Although polystyrene has a big stake in packaging, as do the polyethylenes, it doesn't get the corresponding stability. The reason is that even in packaging, polystyrene, like polyvinyl chloride, is tied too much to expensive durables such as appliances, which slump in recessions. Further, polystyrene—unlike polypropylene—has no big export cushion to fall back on when U.S. business sours. To make matters worse, polystyrene slowly is losing markets to competing materials, especially polypropylene.

So polystyrene is staggering. The long recessionary period since 1979 has cut production fully 20%, and the resin may take much of this decade to climb back. Producers aren't waiting and have begun shutting down plants. Even at a reduced nameplate total of 5.3 billion lb per year, capacity use will run just 60% this year.

For 1982, analysts estimate production at 3.2 billion lb, down 11% from last year's 3.6 billion lb for the worst drop among major thermoplastics. Even if polystyrene resumes its long-term growth rate of 4 to 5% per year, it will take a long time to match 1979 production. If growth declines to 3% annually, a pace predicted by a growing number of industry sources, and another recession occurs later in the 1980s, it could be 1990 before polystyrene regains its old peak.

Behind the slow growth rate are the usual problems of an old material. With mostly mature markets and damage from competing materials, polystyrene suffers low profitability, which holds down money for new market development. A recession simply compounds the fundamental problem.

In packaging markets, the current recession has had a major impact. Since 1979, the cost of polystyrene continued to rise for a while despite producers' efforts to hold the line. The resulting higher prices through 1981 led some customers to switch away and discouraged prospective new customers. Property limitations curb switching somewhat, but the threat remains, and further development work in other polymers could hurt polystyrene even more.

In nonpackaging uses, competition from other polymers, especially polypropylene, also limits polystyrene's growth outlook. For example, housewares, toys, electronic and electrical appliances, and recreational articles are among important outlets threatened by other polymers. In these areas, polymer cost alone can be the critical factor, outweighing any long-run performance requirements. And in any case, many final products have acceptable life spans of just a few months or a year. So if polystyrene's price rises relative to other materials, polystyrene automatically is in trouble.

Competition of a different kind is pruning polystyrene exports. In 1982, analysts expect exports to decline to about 125 million lb from about 150 million lb in 1981. The problem is that technology is readily available for polymerizing styrene. This has led to construction of many small plants for regional markets around the world. U.S. exports of common polystyrene grades can't compete with foreign production when transportation costs are added in. Hence, much of U.S. polystyrene exports are expected to be specialty grades with relatively small volume.

There is one bright spot in polystyrene's future—expandable beads. Analysts predict that beads will grow from a tenth of total polystyrene production at present to one eighth in coming years. The attraction for beads is their insulating and shock absorbing properties. A familiar example is cups for coffee and other hot liquids, which will take 4% of total polystyrene output. Insulation board made of beads, now languishing because of the slump in construction markets, is expected to be another growth area, pulling up total polystyrene consumption over the long run.

Overall, for 1982 and 1983, polystyrene producers will be hard pressed just to hold down market losses. When economic recovery takes hold, part of polystyrene demand may bounce back, but some markets could be gone forever.

NOTE

ONLY THE FOLLOWING PAGES OF THIS

PUBLICATION HAVE BEEN FILMED

Cover 1, p.3, 6, 15-16.

A close look at a biotechnology firm gone bankrupt Page 8

1983 ACS award winners Page 44

Chemical & Engineering NEWS

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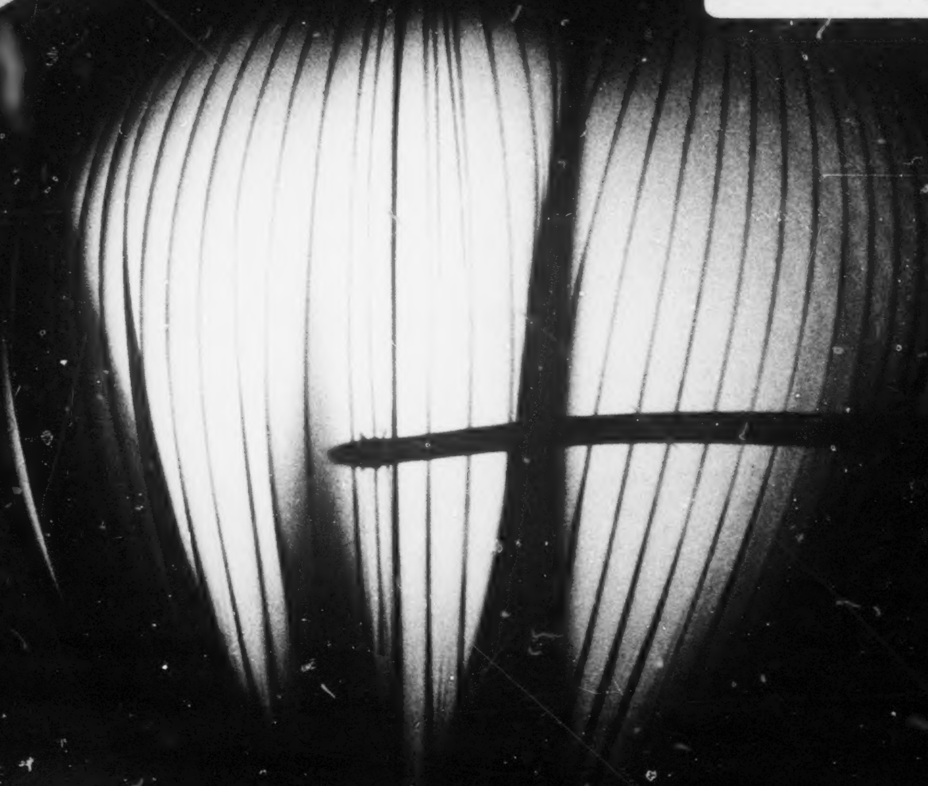

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Stratospheric chemistry

Systematic research replaces crisis response Page 21

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Chemical & Engineering NEWS

Cover: National Center for Atmospheric Research balloon, made of polyethylene and expandable to 15.4 million cu ft at float altitude, is prepared for launch carrying cryogenic whole air sampler. Photo by NCAR's Ginger Wadleigh

4 Letters

Concentrates
13 Business
18 Government
20 Science/Technology

The Departments
40 ACS Comment
72 Newscripts

News of the Week

- ***Top executives in the chemical industry*** *receive highest salaries of all industry groups but rate of salary increases is slowing, study indicates.* **Page 4**
- ***Some 100 unclassified scientific papers withdrawn*** *from international technical symposium after government warning of violation of export-control laws.* **Page 4**
- ***Commercial plant for converting whey to fuel-grade ethanol,*** *to be built for Fermentec in California, will have annual capacity of 400,000 gal.* **Page 5**
- ***New process to recover silver*** *from photographic and offset plate processing that avoids formation of silver sulfide developed by ORNL scientists.* **Page 5**
- ***An electrodeposition method*** *for putting refractory carbide coatings onto metal surfaces has been devised by Naval Research Laboratory scientists.* **Page 5**

News Focus

- ***Armos files for bankruptcy,*** *thus creating another chapter in the small, research-oriented biotechnology firm's struggle with funding, management problems.* **Page 8**

Business

- ***Aerosols beginning a comeback*** *after the controversy over their role in ozone depletion; new raw materials vie for role as propellants.* **Page 15**

Government

- ***Scientists face the problem of national security curbs;*** *State, Commerce, and Defense departments coordinate efforts, and proposed bill calls for new agency.* **Page 19**

Science

- ***Stratospheric chemistry,*** *which gained impetus from perceived threats to the ozone layer in the 1970s, is building up data base, improving modeling techniques.* **Page 21**

Technology

- ***Chemical engineer forms company*** *to provide microcomputer systems tailored to handle particular lab applications.* **Page 35**

Books

- ***"The Monkey Business: A Scientist Looks at Creationism"*** *rebuts creationists' view of evolution as unscientific.* **Page 37**

ACS News

- ***Should ACS hold only one national meeting a year?*** *Pro and con views expressed on question that society members will be asked to evaluate in survey.* **Page 41**

Awards

- ***ACS announces 1983 award winners*** *for outstanding achievements.* **Page 44**

CHEMICAL INDUSTRY TOPS IN EXECS' SALARIES

Chemicals and oil execs are best paid . . .

Industry	1981 average annual executive compensation
Chemicals	$190,319
Petroleum	172,550
Communications	166,874

. . . far surpassing those in lowest-paying industries

Life insurance	103,843
Commercial banking	101,012
Real estate	96,437

Source: Arthur Young & Co

Top executives in the chemical industry lead the list of average total compensation in 27 industries, according to the latest executive compensation study by Arthur Young & Co., a New York City-based accounting firm.

The study, conducted for the Financial Executives Institute, analyzed the pay in 1981 of about 16,500 top executives of more than 1600 companies in 27 industry groups, and in all seven regions of the country. One of its major conclusions: The highest paid top executives are those in the chemical industry, earning an average annual total compensation of $190,319. That topped executives in the petroleum industry, and even those in the communications industry, which usually is associated with show-biz glamor and lavish compensation packages.

Among other conclusions of the study was that the rate of increase in executive compensation was slowed in 1981 from that of 1980 by lower inflation and declining profits. Pay in U.S. corporations increased only 13% on average, down slightly from a 14% average increase in 1980.

Moreover, the study predicts that the rate of increase will decline further this year. Compensation increases tend to lag behind economic conditions, says James A. Giardina, a partner in Arthur Young. Thus, the full impact of 1981 economic results on executive compensation will be realized this year.

This may well lower average total compensation in industries that were hit harder by the recession in 1981 than in 1980. And it possibly might affect the geographic variations that the study picked up, as some areas are hurting more from the recession than others. Top executives working in the Northeast region of the U.S. earned the highest average total compensation, $147,890, which was up 14% from the 1980 average. The Central States region was second, at an average $128,703—but it had the highest average increase. The Rocky Mountain sector had both the lowest average total compensation—$88,501—and the lowest increase, 9%.

Top executives, however, should be forewarned, according to Edwin S. Mruk, a copartner in Arthur Young. Because "executive pay in more than 75% of U.S. corporations is related directly to corporate performance," in many companies that have performed poorly executive pay has been frozen or cut.

And corporate performance will be increasingly important, Giardina predicts. "There is no doubt that companies are placing less emphasis on base salaries and markedly greater emphasis on variable forms of compensation," he says. "The increase in base salaries will lag behind the increase in inflation, and more and more of an executive's total compensation will vary according to performance."

Compensation forms other than salary—such as bonus—are displaying rates of increase significantly higher than those of salary, the study points out. Indeed, bonuses are probably one reason for the chemical industry's rating as high as it does, because of a skewing from such generous grants as the million-dollar bonus W. R. Grace voted its chairman, J. Peter Grace, for 1981. But by the same token, the industry next year well may reflect the salary freezes that chemical companies have put into effect this year. Du Pont and Dow Chemical, for example, have put temporary freezes on salary increases for management and professional employees. □

Pentagon blocks papers at scientific meeting

After a mere reading of titles and abstracts and an in-depth review of about 12 papers, Pentagon officials informed authors of some 100 unclassified scientific papers that their deliverance at an international conference on optical engineering held late last month could violate export-control laws. These authors, Defense Department employees or contractors, withdrew the papers, and by doing so helped set a precedent. Never before has the government caused such a large number of papers to be blocked for not meeting so-called International Traffic in Arms Regulations, or ITARs.

This massive withdrawal deprived attendees (many of them foreigners and several of them from the Soviet Union and other Eastern Bloc nations) at the 26th Annual International Technical Symposium of the Society of Photo-Optical Instrumentation Engineers (SPIE) of fully 13% of the technical material that would have been presented in the some 750 papers listed. All of the withdrawn papers reported on applied research, which one Pentagon official, who asks not to be named, terms "sensitive, defense-related technical information."

These national-security-sensitive papers covered such topics as optical and electrooptical engineering (lasers), high-speed videography, infrared technology, airborne reconnaissance methods, and what the official calls battlefield "obscurance" (smoke) techniques. He says DOD "took extraordinary efforts to head off this potential security disaster," because release of the data would have assisted the Soviets "in the development of things that could be used against us." On the other hand, this official claims that submitted Eastern Bloc papers, which focused on sports medicine and high-speed photography, contained information of little military utility.

SPIE technical director Charles Batishko says his society will work with the government "to assure that a similar situation need not occur again." In fact, many of the withheld papers will be taken through the clearance procedure required by the DOD regulations and may be

Aerosols slowly making a comeback

Outlook brightens as new raw materials contend for role as propellants following fluorocarbon controversy over stratospheric ozone

Patricia L. Layman
C&EN, New York

The aerosol industry has had a lot to contend with over the past decade or so. Countless critics prepared its obituary after the formulation of the ozone-depletion theory by F. Sherwood Rowland and Mario J. Molina (see page 21), taking potshots at the ubiquitous but humble can, which had a market of nearly 3 billion units yearly.

But the industry has confounded many of its critics, proving exaggerated the reports of its demise: Slowly, slowly, it is making a comeback, coping with legislation on environmental and safety grounds. New raw materials are contending for roles as propellants, both in traditional technology and new developments.

And even the latest problem with which it has had to contend—the problem of flammability in large-volume storage—seems to be controllable. If industry studies are accurate, moreover, the designs for protecting against large-scale aerosol fires may prove more efficient, cost-effective systems for use in general fire-safety applications.

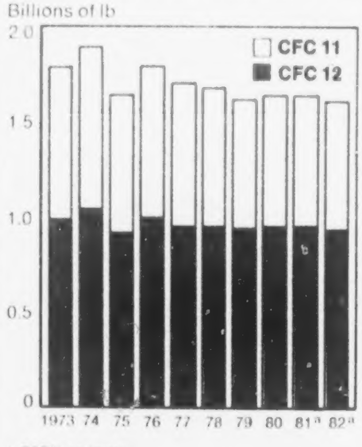
Aerosols had built a market of nearly 3 billion units by 1973. Growth was still smart, probably nearly 10% per year, although many industry marketers predicted at the time a falling off of growth. The two principal market segments—deodorants and antiperspirants, and hair sprays—were reaching saturation points. The worry at the time was where the next big-volume products would be found.

Unfortunately, before those new product areas were stumbled upon, the aerosol industry stumbled over the ozone depletion theory. The theory was fertile ground for joking columnists. It also accounted for a 6.2% drop in sales of aerosols, from 1973 to 1974, as production dipped to 2.72 billion units. Many consumers took the message seriously.

Many swore off aerosols completely, oblivious to chlorofluorocarbons' being the propellants in only about half the aerosols produced. Sales continued to drop—down 13.5% in 1975, down 2.6% in 1976, down another 6.3% in 1977. Those were the official statistics issued by the Chemical Specialties Manufacturers Association; other sources contend that the drops were even more severe.

CSMA surveys indicated a pickup in business again in 1978 and 1979, only to be followed by a nearly 10% decline in production in 1980—the year after the use of chlorofluorocarbons as propellants for aerosols was banned by the federal government. Personal products—for example, hair sprays, deodorants and antiperspirants, perfumes and colognes—was the major category that used chlorofluorocarbon propellants. Many marketers of personal products, which rely heavily on glamor and image advertising, disliked getting involved with something "petroleum-based" (never mind how chlorofluorocarbons are produced) or with the undeniable flammable nature of hydrocarbon propellants. And some consumer-product marketers were convinced that, despite the highly refined grades of propane, butane, and isobutane being used for propellants, there was still a residual odor that mingled with the scent of the product. It might be acceptable for a spray paint or furniture polish, but not for a fine perfume, the argument went. So many marketers took the easy way out: They abandoned aerosols altogether, turning to such alternative products forms as pump sprays, solid sticks, and regular creams and liquids.

Global fluorocarbon output has fallen 14% since 1974



a C&EN estimate
Source: Chemical Manufacturers Association

Over the past two years, however, the industry has been struggling back. CSMA and the National Paint & Coatings Association (NPCA), the two industry trade associations with a heavy interest in aerosols, have sponsored programs to promote the aerosol as a handy, safe package.

And after a wrenching change to hydrocarbon propellants, among those manufacturers who did change, things have settled down to the point that hydrocarbons now account for probably 98% of all aerosols filled. Chlorofluorocarbons are used for some special-exemption categories, primarily for Food & Drug Administration-approved medicinal purposes.

Probably about 60% of the hydrocarbon propellants is isobutane, with propane the next most widely used, with 25%, and *n*-butane the remainder. Rarely is one hydrocarbon used alone; product developers seek to tailor a pressure particularly for their product, and that is generally best achieved by a blend of two or more propellants.

Hydrocarbons originally began moving into the aerosol market as competitors to chlorofluorocarbons because of lower prices. But along with that advantage, manufacturers had to cope with the marked disadvantage of their flammability. This could be a particular problem, of course, when the product itself in addition to the propellant was flammable—alcohol, perhaps—or when the spray might be dispensed around an open ignition source—hair spray applied while a person was smoking a cigarette, for example.

The answer, on an individual-product level, seems to be methylene chloride, which acts as a flame suppressant at a concentration of about 15%. But on an aggregate level, it is another problem completely, and that issue has become the latest assault on the industry.

Fire departments and insurance underwriters worry about the dangers if fire occurs in a warehouse stocked with large numbers of various aerosols. It's not an idle concern: The industry is well aware of several warehouse fires over the past few years that have involved aerosols.

Factory Mutual, an insurance company, several years ago became concerned about the potential of explosions, hydrocarbons contributing to fire spread, and other dangers. For a time, at least, it appeared a distinct possibility that aerosols would be severely restricted as to what kinds of storage would be acceptable to underwriters.

However, studies conducted by Factory Mutual, CSMA, and NPCA have come up with several recommendations that many in the industry believe could lead to more effective safety standards for general warehousing. Among the major recommendations is the need for lower ceilings so that sprinkler heads would be nearer any point of fire, and a more sensitive sprinkler head, with linkages actuating at 165 °F rather than the 286 °F that Factory Mutual now approves. That gives spot control where it is needed.

Even if such warehousing improvements are made over the next few years, however, other propellant suppliers feel the more immediate way to answer the problem is to do away with it. Grow Group's Enviro-Spray aerosol system, for example, works by carbon dioxide pressure, but in a totally different means than the compressed carbon dioxide that has been promoted to the aerosol industry with little success.

And suppliers are beginning to offer highly purified, aerosol-grade lines of dimethyl ether, a propellant used for years in Western Europe and Japan, as an alternative. It can be formulated with high concentrations of water—as high as 50% in some formulations, one supplier says—which not only lessens the problem of flammability but may even open some new opportunities.

Fluorocarbon producers are nearing the end of various tests on fluorocarbon 142b and 22, and preliminary results seem promising for their use as aerosol propellants. Another chlorofluorocarbon, CFC 152a, already is used commercially in one-shot insecticides, the kind set off in a room and allowed to empty totally.

In the meantime, however, hydrocarbon producers are paying attention to their basics, keeping distribution running smoothly, and hoping for new product introductions to spur growth.

One supplier says, "This year, if we see 2 to 3% growth, it'll be pretty good." The recovery will help, whenever it arrives, "because of inventory adjustments. For the past two years, inventories have been at rock bottom," he adds. The resulting replenishment period will cause as much as a 5% growth. However, over the long term, he sees a conservative average growth of 2 to 2.5% a year.

To jazz up those numbers, some marketers feel, will require the introduction of dramatic new products, "to capture the public's attention or interest." Says one, "We need something to take the place of high-volume, daily use items: like hair sprays and antiperspirants." Automotive products, for example, grew 20% from 1980 to 1981—but only to 204 million units filled. "The growth rates look beautiful, but the bases are so small," he adds. "Everyone is looking for that big new product."

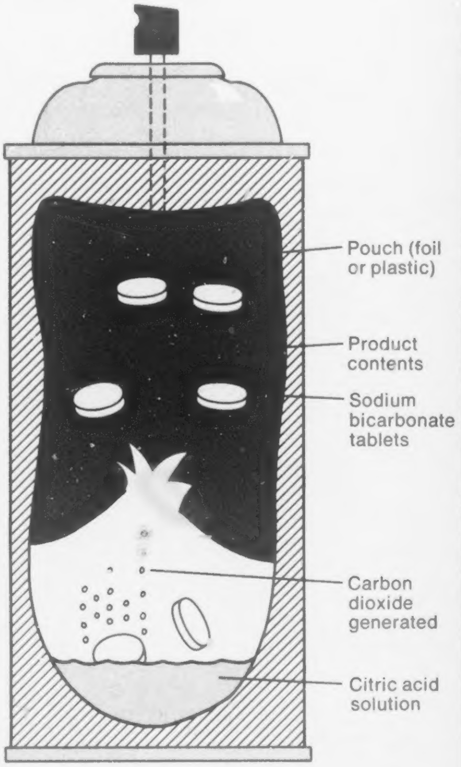
Until that big new product is found for the aerosol industry, it will be a long, slow climb toward recovery. But for an industry once counted out, maybe that's not so bad after all. ◻

Newest aerosol features in-situ CO_2 generation

One of the newest developments in aerosols is Grow Group's "Enviro-Spray" unit, which depends on in-situ carbon dioxide generation. The technology has been around for a number of years, and had a fitful start when Grow, a New York City-based coatings maker, first began promoting it in late 1979. Since then, however, the company has invested time and money in improvement work, and some aerosol industry consultants say the technology finally is beginning to look promising.

As originally patented (U.S. 3,718,236) the technology featured a plastic pouch filled with small compartments containing sodium bicarbonate tablets. Citric acid solution was in the bottom of the pouch, and a small amount of carbon dioxide was charged under pressure into the pouch as a starter propellant. When the product first was dispensed, the carbon dioxide expanded, rupturing the lowest compartment membrane, dropping the bicarb tablets into the citric acid. That generated carbon dioxide, giving more pressure to the pouch, which would expand and help push out more product.

According to David Magid, president of Enviro-Spray Systems, the Grow subsidiary that markets the product, the basic chemistry remains the same, but the product has been modified. The company won't show schematics of the new model, on which it has five patent applications. But they all contribute to making the product an "easier and more accurate gas-producing vehicle," he says. The company has developed a system, he adds, enabling present aerosol production and filling equipment to be used with the product—a crucial point to selling the concept to potential customers, who would be loath to adopt a technology requiring major capital investment.



Grow already is marketing an insecticide for indoor-outdoor plants and has plans for other products. Magid sees, for example, potential markets in such products as caulking compounds, and 1-gal insecticide containers, as well as more conventional markets in personal care and household products, pharmaceuticals, and food products. Most of the company's marketing of products is, in effect, an attempt to show off its technology; as Magid notes, "We are not trying to get into particular competition with other marketers who may be possible competitors."

Chemical & Engineering NEWS
September 20, 1982

Candidates in ACS fall election:
Their views and backgrounds
Page 53

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NUCLEAR POWER

The fight to survive

Page 11

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Cover: Workers help load fuel into reactor core at Florida Power & Light's St. Lucie Unit One in St. Lucie County. Photo courtesy of Atomic Industrial Forum

4 Letters
5 Editor's Page

Concentrates
20 Business
28 Government
34 Science/Technology

The Departments
74 New Products
79 Meetings
92 Books
94 Newscripts

News of the Week

- ***Commerce Department moves to ban*** *shipment of computer-readable magnetic tapes to eastern-bloc countries.* ***Page 6***
- ***Akzona lays off 600 salaried employees,*** *reduces capital spending and working capital requirements.* ***Page 7***
- ***Advisory board review*** *says national labs are doing high-quality work despite handicaps under DOE management.* ***Page 7***
- ***Some 6600 attended ACS's 184th National Meeting*** *held in Kansas City, Mo.; 2400 technical papers were presented.* ***Page 7***
- ***An electrochemical cell that photodissociates water*** *using only visible light as energy source built by scientists.* ***Page 8***
- ***Photographer catches highlights*** *at ACS meeting in Kansas City.* ***Page 9***
- ***Understanding of sickle-cell anemia*** *at the molecular level expected to lead to design of drugs to treat the disease.* ***Page 10***

News Focus

- ***Nuclear power industry*** *must overcome delays in construction, lower growth in electricity demand, high capital costs, poor public image if it is to survive.* ***Page 11***

Business

- ***Polyurethane makers*** *are suffering from the slump in auto and construction markets but Mobay predicts pickup soon.* ***Page 27***

Government

- ***Solar energy moved to back burner*** *as DOE panel recommends dropping unpromising solar technologies.* ***Page 30***
- ***Large research instruments*** *in U.S. universities due to be upgraded through Department of Defense grants.* ***Page 32***

Science

- ***Recent research activity in polymer chemistry*** *may lead to commercial importance; new routes to resins uncovered.* ***Page 37***

Technology

- ***New iron-based catalyst system*** *converts methanol to ethanol without the coproduction of water.* ***Page 41***
- ***Heavy-metal wastes decontaminated*** *in new low-cost process using a specially prepared calcium sulfide slurry.* ***Page 42***

ACS Elections

- ***Candidates for 1983*** *ACS president-elect, directors-at-large, and director for Region I and for Region V give their views on society concerns.* ***Page 53***

ACS News

- ***David Weisgerber*** *named CAS editorial director succeeding Russell Rowlett, who retires after 40 years' service.* ***Page 76***

Troubled nuclear power tries to recover

Even if the industry can overcome its present problems, which range from construction delays, slowing electricity demand, and huge capital costs to public disenchantment, its outlook is hazy at best

Earl V. Anderson
C&EN, New York

Ask if the nuclear power industry has a future and the answer is a simple, straightforward yes.

Ask what kind of a future the industry has and that's when the answer is hazy at best.

Nuclear power has been in trouble—deep trouble—for the past several years. There hasn't been a nuclear reactor ordered since 1978. Far too many, from the industry's point of view, of those that had been ordered have been canceled. Even some that were in advanced stages of construction have been scratched.

Delays and deferrals are commonplace and, as a result, once-ambitious construction schedules are slipping further and further behind targeted on-line dates.

Cost overruns are getting out of hand. Utilities, the customers of nuclear reactor builders, are in deep financial trouble. Unless they are able to get out of their financial bind—and that will be a Herculean task—even more cancellations, deferrals, and delays in nuclear power plant construction are inevitable.

"Streamlining the regulatory process" is still a cliché that has more symbol than substance. Regulations governing nuclear power, although getting better, still are cumbersome, slow, and costly. Yet, with the rash of safety-related problems that have come to light in the past few years, it is unreasonable for the industry to expect too much too soon in the line of regulatory reform.

Public acceptance of nuclear power is much less than enthusiastic, especially since Three Mile Island. And, although there may be some justification to arguments that public fears are more perceived than real, those fears are there nonetheless.

A major reason for public disenchantment with nuclear power is that, after all the years of commercial nuclear power plant operation, there still is no firm solution to the problem of nuclear waste disposal. Technically, safe nuclear waste disposal is possible and has been for some time. But the political minefield has been impassable for a sound nuclear waste disposal policy.

On top of all this, demand for the product of nuclear power plants isn't what it used to be. These plants produce electricity, and the once-attractive growth rate in demand for electricity has slowed to a crawl. Although electricity demand growth likely will pick up again, it never will regain the hefty rates of the late 1960s and early 1970s that spawned dreams of a 1000-giga electron volt nuclear power output by the year 2000.

Taken together, this roll call of problems would spell trouble for any industry. It has spelled exactly that for nuclear power.

Pessimists about the future of nuclear power, at least in the U.S., are a dime a dozen. At a meeting in Ithaca, N.Y., earlier this year, John F. Ahearne, one of the five commissioners at the Nuclear Regulatory Commission (NRC), said, "We are here today in what could be called a wake for nuclear power."

Many other nuclear observers echo these sentiments. "There is no industry to speak of anymore," says one. "There is no recovery in sight," says another.

But optimists are not yet an endangered species. One optimist is Carl Walske. He has to be. He is president of the Atomic Industrial Forum, the industry's trade association. Walske calls himself "a holdover from the Mickey Rooney-Judy Garland movies where the kids could put on their show and save pop's store."

That is an appropriate analogy. Indeed, the nuclear store is threatened by a flock of villains—most of them economic. And all nuclear proponents have going for them is the hope that they can keep the villains at bay long enough for economic conditions to improve. Supporting this hope is one overriding factor: If the economy is to improve, more electrical power will be necessary. With oil and natural gas pricing themselves

New plants will boost nuclear power capacity

Number of reactors	Boiling-water reactor	Pressurized-water reactor	Other[a]	Total	Capacity (MW)
Operating or licensed	**25**	**48**	**3**	**76**	**58,495**
In full power	24	45	3	72	55,061
In power ascension	0	2	0	2	2,328
Shut down indefinitely[b]	1	1	0	2	1,106
Construction permit granted	**26**	**49**	**0**	**75**	**83,288**
Construction at 20% or more	21	38	0	59	64,870
Construction at less than 20%	5	9	0	14	15,858
No construction	0	2	0	2	2,560
Construction permit pending	**5**	**5**	**1**	**11**	**12,714**
Order placed for new plant	**0**	**3**	**0**	**3**	**3,510**
TOTAL	**56**	**105**	**4**	**165**	**158,007**

a Includes two reactors owned by the Department of Energy (Shippingport and Hanford N), and one high-temperature gas-cooled reactor (Fort Saint Vrain), all in operation. Also includes one liquid-metal fast breeder reactor (Clinch River), for which construction is not yet authorized. b Does not include Indian Point I, shut down since 1974 (operating license withdrawn in 1980) or Humboldt Bay (future operation is questionable because of owner's recent withdrawal of application to restart). Units shut down indefinitely include Three Mile Island and Dresden I. **Note:** During the first two months of 1982, seven reactors in the above tally were canceled. These include two which had been granted construction permits, and five others for which construction permits were pending. **Source:** Department of Energy out of the market and with the country supposedly trying to reduce its reliance on these fuels anyway, that leaves the economic future of the country squarely on the shoulders of nuclear power and coal.

But even if nuclear power can survive the troublesome present and make it to the future, that future, as one wag put it, "ain't what it used to be and never will be."

Years ago, nuclear power's future looked promising. In the late 1960s and early 1970s, when electricity demand was averaging a 7% annual growth rate and expected to continue that way indefinitely, orders for nuclear power reactors came pouring in.

In a nine-year stretch between 1966 and 1974, orders were placed for 218 reactors with a combined capacity of 224,077 MW. That's about 90% of all the nuclear power capacity ordered since civilian nuclear power began.

After that, reactor orders slowed to a trickle. In the following four years, only 13 reactors with a combined capacity of 15,232 MW were ordered. Since 1978, not a single order has been placed for a nuclear power reactor. Undoubtedly, lower electricity growth rates, a poor economy, and a financially troubled utilities industry helped trigger the drought. In addition, the fact that the worst accident in nuclear power's history—Three Mile Island—occurred in March 1979 also had to have an impact.

Order books for nuclear power reactors have shown nothing but cancellations ever since. In fact, the rush to cancel orders already placed started as far back as 1974. The stark reality is that, compared to 13 reactors ordered since 1975, 78 reactors have been canceled. Compared to 15,232 MW of nuclear power capacity that was ordered since 1975, a whopping 84,970 MW were scratched from the books.

Cancellations still are the order of the day. During the first half of the year, another eight reactors (9900 MW) were scrubbed by four utilities.

The cancellation list is certain to grow bigger. For instance, last month Tennessee Valley Authority (TVA) scrapped further construction on four partially completed nuclear power plants. Blaming dwindling electricity demand, TVA believed that it would be cheaper for its customers to cancel the units than to keep them on hold until construction was justified again.

Mid-1960s, early 1970s were good years for nuclear reactor orders; late 1970s were bad because of cancellations

	Total orders placed		Later canceled		Net orders[a]		Cancellations by year of cancellation	
	No. of units	Net MW	No. of units	Net MW	No. of units	Net MW	No. of units	Net MW
1953	1	60	0	0	1	60	0	0
1955	2	465	0	0	2	465	0	0
1956	1	175	0	0	1	175	0	0
1958	1	65	0	0	1	65	0	0
1959	1	72	0	0	1	72	0	0
1962	2	630	0	0	2	630	0	0
1963	5	3,018	1	462	4	2,556	0	0
1965	7	4,475	0	0	7	4,475	0	0
1966	20	16,526	0	0	20	16,526	0	0
1967	31	26,462	2	1,482	29	24,980	0	0
1968	15	14,018	1	1,115	14	12,903	0	0
1969	7	7,203	2	2,137	5	5,066	0	0
1970	14	14,264	1	583	13	13,681	0	0
1971	21	20,957	10	9,864	11	11,093	0	0
1972	38	41,313	18	19,007	20	22,306	6	5,002
1973	38	43,319	15	15,876	23	27,443	0	0
1974	34	40,015	24	27,724	10	12,291	9	9,516
1975	4	4,148	4	4,148	0	0	10	11,729
1976	3	3,804	2	2,534	1	1,270	5	5,090
1977	4	5,040	4	5,040	0	0	10	10,814
1978	2	2,240	0	0	2	2,240	11	11,287
1979	0	0	0	0	0	0	13	15,252
1980	0	0	0	0	0	0	14	15,501
1981	0	0	0	0	0	0	6	5,781
TOTAL	**251**	**248,269**	**84**	**89,972**	**167**	**158,297**	**84**	**89,972**

[a] Remaining orders after subtracting cancellations by year of order. **Note:** The years 1954, 1957, 1960, 1961, and 1964 are omitted because there were no orders nor cancellations. **Source:** Department of Energy

Last month, too, Houston Lighting & Power Co. dropped its plans to build its Allens Creek nuclear power plant in Austin County, Texas. Although economics shares some of the blame, the company cited continuing delays in getting a construction permit from NRC as a primary reason. Construction had not yet begun when HLP called it quits. Yet, the company ordered Allens Creek units 1 and 2 in 1973 (and canceled unit 2 in 1976).

Many reactors that have escaped the cancellation block have run smack into another problem: delays.

According to Department of Energy (DOE) statistics, an average of 66 nuclear power plants were hit by one kind of delay or another in each of the past seven years. Over these years, the average delay was 16 months per reactor in each year.

The total slippage for the period is staggering. It amounts to a whopping 7480 months. This means that, since 1975, 89 reactor years have been lost to delays in nuclear power plant construction.

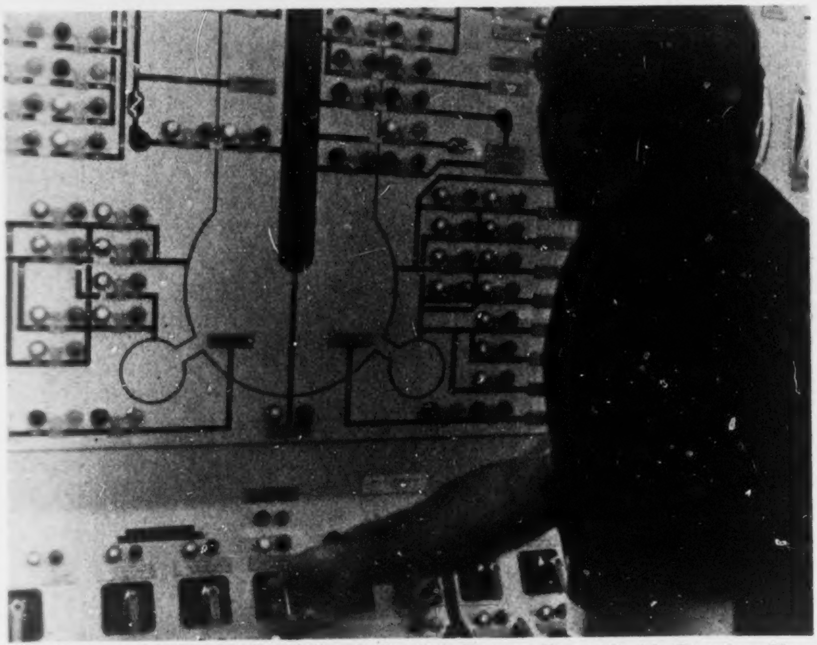
Certainly, the regulatory maze, intervenor litigation, and on-site demonstrations by antinuclear groups have contributed to these delays. But the industry itself must shoulder some of the blame. Overoptimistic construction schedules account for some delay. Labor problems and poor labor productivity also are factors. Sloppy work that had to be corrected and a host of other problems that cannot be attributed to anything but industry shortcomings have added to the delay problem.

Whatever the reasons, delays are costly. Take, for example, the Millstone 3 nuclear power plant of Northeast Utilities in Waterford, Conn. The unit, now 52% complete, originally was scheduled to go on line in 1979. Now the date is 1986.

Two years ago, Northeast estimated the plant would cost $2.6 billion. This year's estimate is $3.54 billion, a painful $940 million more.

In Missouri, Union Electric Co. says that its Callaway 1 reactor will be another year late coming on line. Now the target is late 1984 or early 1985. As a result, the company has raised the plant's estimated cost from $2.1 billion to $2.85 billion. Original price tag for Callaway 1, which was supposed to be finished next year: $1.6 billion.

This gloom-and-doom dirge, how-



Control panel at Tennessee Valley Authority's Browns Ferry plant in Decatur, Ala.

ever, masks the fact that there is a big slug of nuclear-generated capacity now operating in the U.S. and contributing significantly to the country's electricity supply. AIF's latest scorecard (midyear) shows 81 reactors with operating licenses and a combined capacity of 62,705 MW.

In reality, only 73 reactors (56,196 MW) are in commercial operation. Three others have low-power operating licenses, Pacific Gas & Electric's Diablo Canyon 1 in California has had its low-power operating license suspended, and four reactors have been shut down indefinitely.

Still, nuclear power plants accounted for 12% of U.S. electricity output last year. In some regions, nuclear's share is much higher, particularly in the eastern and central portions of the country. In New England, for instance, nuclear power contributed 33.5% of all electricity generated last year.

In his midyear outlook for the industry, AIF's Walske says that if nuclear power maintains its present momentum, it could land in second place this year as a source of electricity behind coal, which supplies more than half of the total.

That may be asking a lot of nuclear power. DOE's Energy Information Administration estimates that nuclear power this year will generate 313 billion kWh of electricity. That's a nifty 15% increase, but still only good enough to account for 13% of total electricity output. Unless something drastic happens to natural gas, which has held second place for many years with about a 15% share, nuclear power will retain its still-respectable third spot in 1982.

Next year, however, may be nuclear's year for the runnerup position. In 1983, another 10 or 11 nuclear power plants (depending on the amount of delay encountered) are expected to come on line. These units will add between 10,000 and 11,000 MW to total U.S. nuclear capacity.

In addition to those reactors with operating licenses, AIF tallies an additional 77 reactors in the pipeline; 69 of them have construction permits, and another eight reactors are on order.

If its yearly schedule of additions is correct, AIF says that, by 1990, there will be 137 nuclear power plants in the U.S. with a total capacity of 122,512 MW. That's both encouraging and disappointing to the industry.

It's encouraging because it means that nuclear power capacity will double in just eight years. That's more than most elements of the economy will be able to say. But compared to the 251 units and 248,000 MW that were, at one time, on order, it's very discouraging.

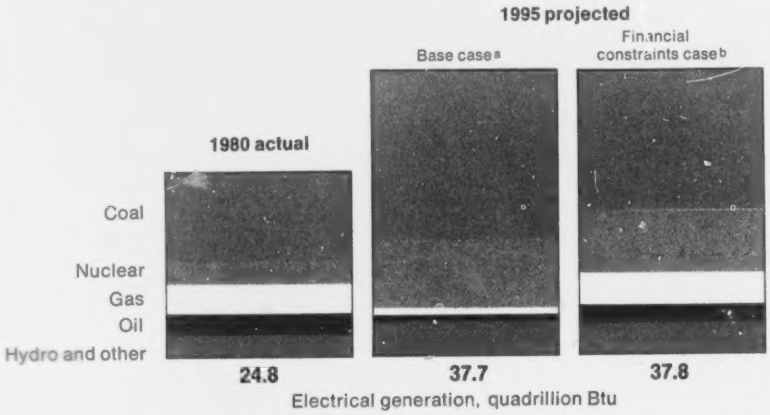
It's also possible—probable is more like it—that some of these units will fall victim to the cancellation ax. At least 17 nuclear power plants still are less than 25% complete.

Recent cancellations involved several units that were along in construction. Washington Public Power Supply System's plant 4 was more than 15% complete when construction was halted earlier this year.

How many nuclear power plants in the pipeline actually will be completed depends primarily on the utilities. If current projections for a 3%-per-year growth rate for electricity demand prove accurate, utilities will have to invest an estimated $365 billion (1981 dollars) by 1990.

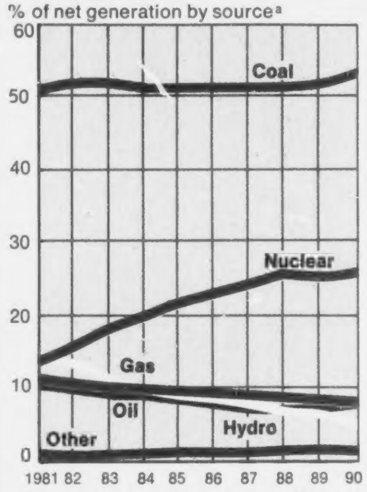
But the utility industry is a financial basket case. Once the bluest of blue chips, utility stocks and bonds have lost their luster.

Utilities' financial plight could mean more oil and gas consumption, less coal and nuclear



[a] Utilities able to obtain financing for all new construction currently planned and additional power plants justified by economics. [b] Utilities unable to obtain financing for many new projects and are able to build only those units for which they already have a major financial commitment. Under these conditions, utilities build only about 50% of coal power plants currently under construction or planned and about 80% of nuclear power plants under construction or with a construction permit. **Source:** Department of Energy

Nuclear's share of electrical power generation to climb



[a] Totals add up to slightly more than 100% because pumping energy has not been deducted. **Source:** Edison Electric Institute

Utilities, because they are highly capital intensive, have been hit particularly hard by inflation and high interest rates. Nuclear power plants are especially capital intensive.

According to DOE, real construction costs have jumped 100% between 1971 and 1980. And it estimates that construction costs for plants coming on line in 1995 could increase another 60 to 100% in constant 1980 dollars.

Today, it's not unusual for a large nuclear unit to cost up to $3000 per kW of capacity. By comparison, plants already operating are in the $400- to $500-per-kW range.

To make matters worse for the utilities, public utility commissions normally don't allow them to increase rates until the new unit actually is generating electricity. The reason: They don't think that customers should pay for something that they don't yet have. As a result, utilities must finance new construction by selling stocks and borrowing.

When power plants were smaller, less expensive, and quicker to build, utilities were able to handle the financial load until rate increases started flowing in. Now, however, with new plants larger, much more expensive, and taking 12 to 13 years to build, utilities find the financing burden almost unbearable.

It's not surprising, then, that utilities are going all out to reduce capital requirements as much as possible. As a result, fewer plants, both coal and nuclear, are being ordered and built. The cutback also accounts for many of the cancellations and deferrals that have taken place.

Although this strategy may ease the short-term financial problems of both the utilities and their ratepaying customers, it could signal more severe problems later for the entire economy if the link between gross national product (GNP) growth and demand for electricity holds.

This is where the uncertainty comes in for the nuclear power industry, the utilities industry, and for just about every other industry for that matter. How fast will GNP grow? How fast will demand for electricity grow?

There are no shortages of forecasts. But the disparities in forecasts of future economic, energy, and electricity growth only add to the confusion.

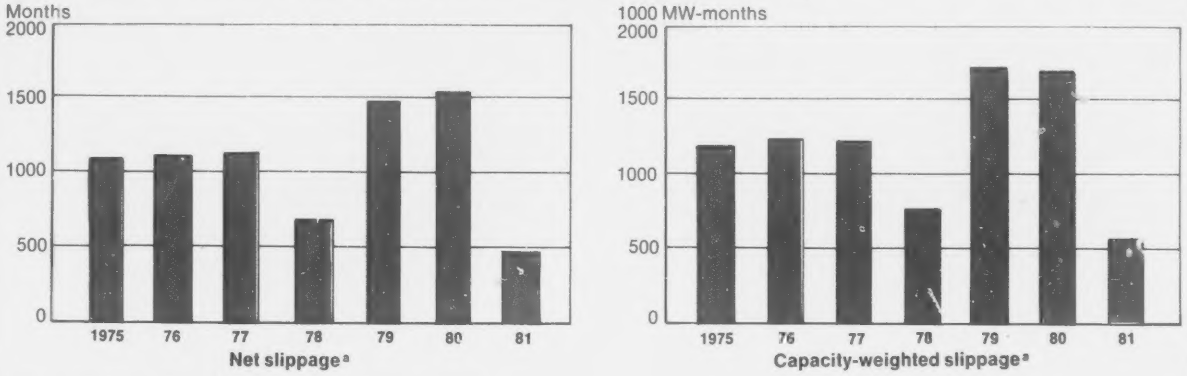
Supply-side Reaganomics, for instance, is predicated on the presumption that GNP will grow at an average annual rate of 4 to 5% during the 1980s. But in its latest annual report to Congress, DOE's Energy Information Administration (EIA) based its energy projections on an average GNP growth of about 2.5%.

What does this mean for electricity? There is a critical relationship between the two. From the 1950s through the 1970s until the Arab oil embargo, electricity consumption grew about twice as fast as GNP. That ratio has fallen off since the

Growth in electrical output has declined, but coal and nuclear have increased their share

	Electric power generation, billions of kWh													
	Nuclear		Coal		Oil		Gas		Hydro		Other[a]			% annual change
		% of total		% of total		% of total		% of total		% of total		% of total	Total	
1960	1	0.1%	403	53.5%	46	6.1%	158	21.0%	146	19.4%	b	c	753	6.1%
1961	2	0.3	422	53.3	47	5.9	169	21.3	152	19.2	b	c	792	5.2
1962	2	0.2	450	52.8	47	5.5	184	21.6	168	19.7	b	c	852	7.6
1963	3	0.3	494	53.9	52	5.7	202	22.0	166	18.1	b	c	917	7.6
1964	3	0.3	526	53.5	57	5.8	220	22.4	177	18.[illegible]	b	c	984	7.3
1965	4	0.4	571	54.1	65	6.2	222	21.0	194	18.4	b	c	1055	7.2
1966	6	0.5	613	53.7	79	6.9	251	21.9	195	17.0	1	0.1%	1144	8.4
1967	8	0.7	630	52.0	89	7.3	265	21.8	222	18.3	1	0.1	1214	6.1
1968	13	1.0	685	51.5	104	7.8	304	22.9	222	16.8	1	0.1	1329	9.5
1969	14	1.0	706	49.0	138	9.6	333	23.1	250	17.3	1	0.1	1442	8.5
1970	22	1.5	704	47.2	184	12.0	373	24.6	248	16.6	1	0.1	1532	6.2
1971	38	2.4	713	44.2	220	13.6	374	23.2	266	16.5	1	0.1	1613	5.3
1972	54	3.1	771	44.1	274	15.6	376	21.5	273	15.6	2	0.1	1750	8.5
1973	88	4.5	848	45.6	314	16.9	341	18.3	272	14.6	2	0.1	1861	6.3
1974	114	6.1	828	44.4	301	16.1	320	17.1	301	16.1	3	0.1	1867	0.3
1975	173	9.0	853	44.5	289	15.1	300	15.6	300	15.6	3	0.2	1918	2.7
1976	191	9.4	944	46.3	320	15.7	295	14.5	284	13.9	4	0.2	2038	6.3
1977	251	11.8	985	46.4	358	16.9	306	14.4	220	10.4	4	0.2	2124	4.2
1978	276	12.5	976	44.2	365	16.5	305	13.8	280	12.7	3	0.2	2206	3.9
1979	255	11.4	1075	47.8	304	13.5	329	14.7	280	12.4	4	0.2	2247	1.9
1980	251	11.0	1162	50.8	246	10.8	346	15.1	276	12.1	6	0.2	2286	1.7
1981[d]	272	11.9	1202	52.4	206	9.0	345	15.1	261	11.4	6	0.3	2293	0.3

[a] Includes wood, geothermal, and waste. [b] Less than 0.5 billion kWh. [c] Less than 0.05%. [d] Preliminary. **Source:** Department of Energy



Years of construction delays plague the nuclear power industry

a Net of delays minus advances in schedules. **Source:** Department of Energy

embargo, but electricity demand still has grown an average 1.5 times faster than GNP.

To Peter Navarro, a researcher at Harvard University's Energy & Environmental Research Center, this suggests a rough rule of thumb: GNP can't grow substantially faster than growth in electricity demand. In fact, if the country expects to reduce its dependence on oil in general and imported oil in particular, the GNP-electricity linkage can grow only stronger.

That, too, is a big if for the nuclear power industry. It implies that nuclear—and coal—must play a bigger role in generation of electricity. Those are the only two logical substitutes for oil and natural gas in central power stations.

Forecasts of electricity demand also do little to help utilities make definite plans for the future. A recent sampling has 1980 to 1990 demand growth ranging from 1.6 to 4.5% per year. Most forecasts, however, zero in on 3.0 to 3.5%.

If those figures are right, GNP growth as seen through the eyes of Reaganomics will be all but impossible to realize. But a GNP growth rate of 2.5 to 3.0% annually could be achieved.

Will there be enough generating capacity in 1990 to satisfy demand for electricity? The North American Electric Reliability Council (NAERC) forecasts a 3% annual net increase in capacity in the 1980s. That's borderline to meet projected demand.

To make matters worse, NAERC also points out that more than half of the planned capacity has been delayed an average of 20 months. It's likely, too, that some proposed units will be canceled. Some already have been. It's entirely possible, then, that capacity growth will be something less than 3%, which may not be enough to meet demand. The result could be brownouts, blackouts, and not enough electricity to support industrial growth.

The only alternative is to retreat back along the path to more oil and gas, something the country wants to avoid.

A study made last year by DOE's EIA indicates what could happen. It analyzed two possible alternatives for the nation's investor-owned utilities. In one (the base case), it assumes that utilities are able to obtain financing for all new, planned construction projects and for any additional plants justified by economic conditions.

The financially constrained case assumes that many utilities are unable to obtain enough financing for many new projects. They are able to build only those plants for which they already have made a major financial commitment.

Under these conditions, utilities build only about 50% of the coal-fired plants now planned or under construction and about 80% of nuclear power plants under construction or with a construction permit.

The study concludes that, if electricity demand increases 3.2% per year through 1995, many coal-fired and nuclear-powered plants could be delayed under the base case. But to do that, additional combustion turbines will have to be installed to guarantee regional and national reliability (an average national reserve margin of 23%). This reserve margin will have to be much higher in some regions.

If financial restraints still plague utilities, they will have to rely on much more oil and natural gas to meet electricity demand. In 1995, oil's share of total electricity generation will jump from 0.8% under the base case to 6.1%. For natural gas, the figures are 2.4% and 10.8%, respectively.

Nuclear and coal, of course, will be the big losers. Instead of generating 24.1% of all electricity in 1995, nuclear will generate only 21.7%. Coal will slip badly, from 61.5% to 52.4%.

If utilities can't break their financial chains, oil imports in 1995 will be 800,000 barrels per day higher than they otherwise would be. That's a deplorable 23.5% increase. Prices that consumers pay for their electricity will be 8% higher as a national average. But in some regions, the bills will be 24% higher.

Thus, if financing problems prevent utilities from building the more economical coal-fired and nuclear plants, not only will oil imports and fuel bills increase, but the country will lose an opportunity to eliminate about 82% of the oil and natural gas that utilities now use.

EIA's study doesn't include what may happen after 1995. But, with the long lead times that are necessary for coal-fired plants (seven to 10 years) and nuclear plants (11 to 13 years), continued delays and cancellations imply that there may not be enough capacity to meet demand after 1995, even with the addition of combustion turbines.

Suppose, though, that the utilities are able to overcome their financial problems and that they do start ordering large, efficient generating units again. Will they order nuclear, or will they order coal?

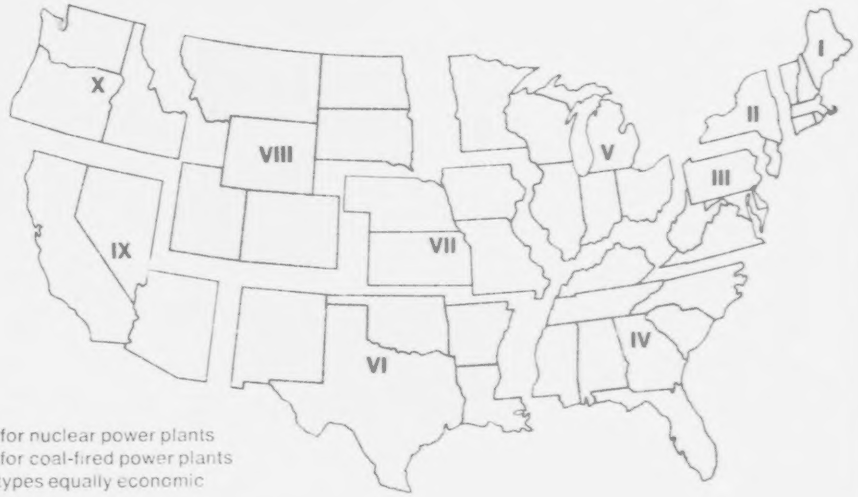
Many an argument has been triggered on the subject of which fuel generates the least expensive electricity. Basically, capital costs are

Future nuclear vs. coal generating costs depend on location

Comparative bus-bar costs, mills per kWh[a]

Region	Nuclear	Coal
I	43.0	46.8
II	45.0	44.1
III	41.9	41.1
IV	40.6	44.1
V	43.5	42.4
VI	40.6	29.5
VII	42.5	42.9
VIII	42.3	31.0
IX	44.8	44.8
X	44.8	46.5

[a] In 1980 dollars over 30-year plant life.



☐ Advantage for nuclear power plants
☐ Advantage for coal-fired power plants
☐ Both plant types equally economic

Note: For plants coming on line in 1995. Advantage implies that one plant type has a cost differential greater than 5% over the other plant type. If cost differentials are less than 5%, both plant types are considered economic choices. **Source**: Department of Energy

much higher for nuclear plants than for coal-fired plants. But, compared to coal, nuclear fuel costs are extremely small. On these two points, there is no argument.

It is how many other factors are pumped into or left out of the equation that leads to controversy. The problem is such that, in a recent DOE study on comparative costs, it offered a guideline and a methodology for doing economic analysis, particularly of nuclear- and coal-powered generation.

One of the most publicized pro-coal studies was prepared by Charles Komanoff of Komanoff Energy Associates. He predicts that future nuclear power plants will cost so much more than coal-fired plants that their "lifetime generating costs will exceed those of new coal plants by 20 to 25% on average."

He also claims that Three Mile Island-related costs will drive the difference to 35 to 50%. "Many reactors under construction could be scrapped with little or no economic penalty," says Komanoff.

The nuclear industry, the utilities, most independent consultants, and a string of government studies disagree. "If Komanoff is right, then obviously there is no future for the nuclear industry, and a lot of other things, too," says one critic of the Komanoff study.

A major complaint about the study is its choice of capacity factors. Capacity factor, a key gauge in power plant performance, is the ratio of kilowatt-hours a plant actually produces to what it could have generated running 24 hours a day each day of the year. The higher the number, the better the performance.

Selecting the proper capacity factor is important. New power plants, both coal and nuclear, are expensive. Carrying charges on invested capital will dominate electric power generating costs.

A low factor spreads annual carrying charges over fewer kilowatt-hours and raises generating costs. Komanoff assumes a 60% capacity factor for nuclear and a 70% factor for coal. According to A. David Rossin, director of research at Commonwealth Edison (Chicago), experience points the other way.

Average capacity factors for all U.S. nuclear power plants were 62.4% in 1977 and 65.2% in 1978. They dipped below 60% in 1979 and 1980, but that was in the aftermath of Three Mile Island. Some nuclear proponents say that nuclear capacity factors could be as high as 70%.

Nuclear advocates have plenty of studies to choose from that prove nuclear's cost advantage over coal. A recent one comes out of Sargent & Lundy Engineers (Chicago). The company, which designs both coal and nuclear plants, has conducted similar studies in the past and consistently has found lifetime levelized nuclear generating costs to be lower than those of coal.

In this year's study, William W. Brandfon, associate head of Sargent & Lundy's analytical division, says that nuclear has a 4.7% edge over high-sulfur coal and a 13% edge over low-sulfur coal. This study uses a 60% capacity factor for both coal and nuclear plants.

Even the staunchest nuclear advocate concedes that, as nuclear plant costs escalate, their cost advantage over coal-fired plants narrows. However, they are quick to add that large, coal-fired plants aren't immune to cost-escalation either.

A new report issued just last month by EIA may take some of the wind out of both sides' sails.

The study analyzes the relative economic merit of nuclear vs. coal-fired electricity generation for new plants beginning baseload service in 1995. Not a bad choice of years, because it would take almost until then to bring a new nuclear unit on line if the investment decision were made today.

EIA has come up with comparative levelized bus-bar costs over a 30-year plant life. Its conclusion: a tossup.

The agency concludes that, as a national average, nuclear-generated electricity would cost 42.9 mills per kWh and coal-based power would cost 41.3 mills per kWh. The advantage falls to coal, but it's really too close to call.

More important are regional cost variations, the result of differences in labor and material costs, coal characteristics, and transportation distances and costs.

Coal has a distinct advantage in the

North Central and Southwest regions, primarily because of very low projected coal costs in these regions. Nuclear also has an edge in two regions—the South Atlantic region and New England for exactly the opposite reason. In the six remaining regions, both types of plants are equally economic. EIA defines a plant as having an advantage only if it has a 5% or greater edge in generating costs.

Another important conclusion of EIA's report is that in no region of the country are oil- and gas-fired plants economic alternatives to nuclear and coal.

What all of this adds up to is what really has been taken for granted all along: Both nuclear and coal-fired power plants will be needed in the future, one more so than the other in some regions of the country.

Some antinuclear forces can and do argue for the all-coal route. Theoretically, that is possible. It's not very practical, however. Logistics alone work against it. Mining and transporting all of the coal that would be required would be a huge task. Environmental problems would escalate. Besides, as one observer put it, "Competition is good for the soul—and for power plant customers."

It's easy to see why AIF's Walske says that three of nuclear power's biggest problems are "money, money, and money." Financial aspects are, of course, very important, but the industry cannot escape the fact that it has several other headaches to overcome, too.

Nuclear power is, after all, not only an economic animal, but a political and emotional animal as well.

Just how political nuclear power can be became apparent during the Carter Administration. That Administration, unlike its predecessors, never firmly committed itself to the nuclear option. President Carter publicly described it as the "technology of last resort," fought the antiproliferation fight, and banned nuclear fuel reprocessing.

With the election of President Reagan, the political winds changed. The Reagan Administration enthusiastically endorses nuclear power and breeder technology coupled with reprocessing of spent nuclear fuel.

The Administration's commitment to regulatory reform also is apparent at NRC. The industry places much of the blame for its plight squarely on a labyrinthine regulatory process. Some of that blame undoubtedly is deserved; some of it isn't.

Under the leadership of chairman Nunzio J. Palladino, a determined effort is under way at NRC to revamp the power reactor licensing process and to propose legislation for one-step licensing of standardized plants.

Commissioner Victor Gilinsky has some reservations about all of this. Granting that some regulatory reform is long overdue, he nevertheless wonders about priorities. He senses a new mood among NRC staffers.

"Some of the very same senior NRC officials who were outdoing each other three years ago in proposing new safety requirements now are competing to eliminate such requirements," he says. And he wonders about the possibility that any NRC office that proposes new requirements for licenses may have to submit a detailed cost-benefit analysis along with it.

Nevertheless, regulatory reform is under way at NRC, reform that could affect both plants already under review and new license applications.

For plants already under review, possible changes in hearings formats are getting a lot of attention at NRC. Safety goals, along with numerical guidelines and wider use of probabilistic risk assessment techniques, are being reviewed.

For new license applications, an NRC task force is preparing a legislative proposal that would encourage completely standardized plants. Such an approach conceivably could improve the licensing process because both the nuclear industry and its regulators could concentrate on only a few plant designs.

This legislative effort visualizes giving NRC the authority to approve standardized plants independently, even before a company makes a specific application to build one. Any approved design would have a time limit on it. The thinking now is about five to 10 years. Thus, industry still will have an incentive to come up with new, improved designs.

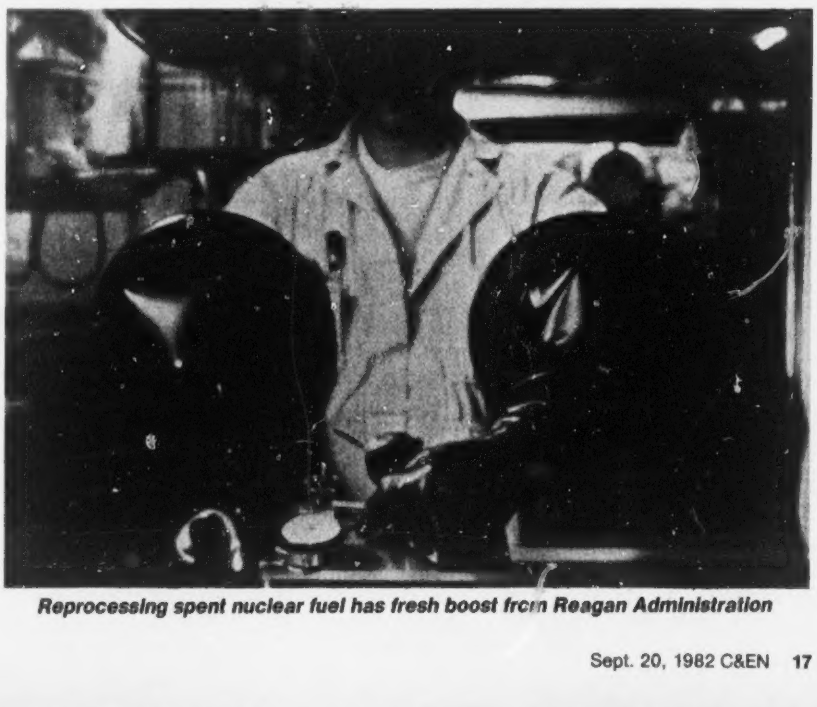
Another part of the standardized plant package is preselected siting. NRC could approve a site for one or more nuclear power plants, again before an application to build a plant there is even made.

Potentially more important is a proposal that would enable NRC to issue a combined construction permit and operating license. These now require two separate regulatory procedures.

Industry also has complained long and loud about the flood of backfitting requirements that pour out of NRC, especially since Three Mile Island. The Administration wants to limit demands for backfits and, at NRC, its new Committee for Review of Generic Requirements (CRGR) may push it in that direction.

Industry feels that NRC has a tendency to order backfits only because they offer some safety improvement, even when there is absolutely no doubt about a plant's present safety level. And many experts are skeptical that CRGR will be enough to solve the backfit problem. They think that Congressional action on licensing reform may be needed.

NRC chairman Palladino says that with standardization, early siting, and combined action on construction



Reprocessing spent nuclear fuel has fresh boost from Reagan Administration

permits and operating licenses, many of the regulatory problems that have made nuclear plant construction so costly and time-consuming will be solved.

The nuclear community is not all that sure. It concedes that NRC has made improvements in the regulatory process. But it still is not certain that those improvements will help reduce runaway costs or spur a revival of new orders. And it continues to see stability in the regulatory process as a distant goal.

Commissioner Gilinsky thinks that this emphasis on licensing reform for future nuclear reactors makes little sense. "What good is it," he asks, "if there are no new orders?" He believes that both regulators and industry should be concentrating on plants now operating and those under construction.

According to Gilinsky, plants that are almost complete may not go into operation on schedule, not because of regulatory delays, but because they haven't been built right. Diablo Canyon's well-publicized seismic design problem is only one example. There are others.

Even in operating plants, there are safety-related problems. Embrittlement, one of NRC's high-priority, but unresolved issues, is one of them. Old reactor vessels subjected to certain conditions of high pressure and rapid cooling could rupture and release radioactive material into the containment building. Core meltdown is a possibility.

Steam generator problems are attracting much attention, especially since a steam generator tube ruptured and released small amounts of radioactive steam at the Robert E. Ginna plant in Ontario, N.Y. Most steam generator problems concern corrosion and mechanically induced tube and tube-support plate damage.

Industry officials concede that these and other safety problems exist. The problems are not new, they say, only the heat of the publicity is. Most of the problems have been recognized for years and, although some of them still are unresolved, they haven't gone unattended.

Solving these problems successfully and quickly could give a big boost to the prospects of the nuclear option. Gilinsky believes the entire industry is hostage to the worst performers in it. And he doesn't think that nuclear power can stand another serious accident, even if no one is hurt. "Another Three Mile Island," says Gilinsky, "and you can kiss Wall Street financing good-bye."

There are few people in the world who haven't heard about the loss-of-coolant accident at General Public Utilities' unit 2 near Harrisburg, Pa., in March 1979. Although the reactor core was damaged severely, containment was not impaired. Once coolant flow was restored, there was no possibility of a meltdown or core rupture. Only negligible amounts of radiation were released, no more than normal background radiation levels in high-altitude cities.

The press, however, played up Three Mile Island as an impending disaster. NRC suspended licensing and didn't issue another license until August 1980, almost a year and a half later. NRC, along with Congress and the Kemeny Commission, conducted reviews of nuclear safety and licensing procedures.

To the utilities, one of the most important lessons of Three Mile Island was a lack of adequate operator training. The man-machine interface has taken on a new significance. Suppliers are paying more attention to human factors in their instrument and control design.

Less than one month after the Three Mile Island accident, the industry created the Nuclear Safety Analysis Center to investigate the accident and to provide technical advice and support on safety-related matters. The center operates as a division of Electric Power Research Institute.

The Institute of Nuclear Power Operations also was formed to focus on operational aspects of nuclear power plants. It concentrates on training, staffing procedures, and plant management.

Three Mile Island probably did more to sour nuclear power in the minds of the public than all of the antinuclear sloganeering that preceded it. Indeed, public acceptance, or lack of it, has to rank right along with financial, economic, and technical problems as a major industry concern. The industry knows this, and utilities soon may launch a public information program to woo the public back to nuclear power.

Aside from keeping its safety record clean and avoiding another major nuclear accident, nothing could do more to improve nuclear power's

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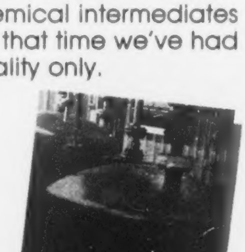

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public image than to finally come to grips with a national nuclear waste management program for high-level waste. "If the antinukes lose waste, they lose the ideal albatross," says one industry official.

Although a nuclear waste disposal policy definitely is a problem for industry, it requires a government solution. The Atomic Energy Act gives the federal government exclusive responsibility for disposing of high-level wastes generated from both civilian and military reactors. DOE will handle the actual job; NRC will handle the licensing.

Technically, safe high-level waste disposal is possible and has been for years. One method is to separate and concentrate the waste by reprocessing spent fuel, convert it into a dry solid, fuse it with glass, and seal it in a metal cannister. The process also can be adopted to unreprocessed spent fuel assemblies.

Present plans call for burying the waste permanently in deep geologic formations. These formations have been stable for millions of years and are expected to remain so for millions of years more.

The holdup has been in Congress. Finally, this past April, the Senate passed, by an overwhelming 69 to 9 vote, a bill that would establish a national waste policy for the first time.

Now, it is up to the House. Four different House committees have reported out three different waste bills. Committee staffs are reconciling them into a consensus bill that will have to be acted upon by the House Rules Committee. Then a Senate-House conference will have to resolve any differences in the legislation.

If Congress is able to translate a national waste disposal policy into law, it will eliminate one of nuclear power's biggest headaches. If NRC is able to cut some of its regulatory red tape and shorten lead times, it will eliminate another one.

These are two big "ifs." Meanwhile, it is industry alone that must compile a spotless safety record and restore public confidence. Some say it can't be done. The industry believes it already has rolled up a good safety record, but it can't afford to rest upon whatever laurels it thinks it has.

The nuclear power industry also must do whatever it can to overcome cost escalation and financing problems. But in the final analysis, nothing will do more for the revival—indeed, the survival—of nuclear power than a good swift kick in the pants of the economy. □

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Slump in polyurethanes continues

1982 consumption will be the same as or below 1981 level, but producers see some improvement by the end of the year

Producers of polyurethane products are going through the same sorts of pangs that makers of most other chemicals are experiencing. In other words, poor construction and automobile markets are taking their toll on the urethanes industry.

However, at least one producer—Mobay—says there may be some hope. A survey of the industry by Mobay, the U.S. arm of West Germany's Bayer A.G., shows that demand in 1982 may be a reverse image of 1981 with slow demand at the beginning of the year and a pickup toward the end. Other suppliers to the polyurethane industry agree with this assessment, but they are not sure that demand in 1982 will equal that of 1981.

Since there are no official figures on polyurethane production or demand, either from the government or trade groups, urethane chemical producers have moved in to fill the void. In the past, Upjohn has provided a yearly survey of polyurethane demand, but did not this year. So Mobay has conducted its own survey, interviewing polyurethane producers and various end market trade groups to get its data.

Mobay's survey indicates that U.S. consumption of flexible polyurethane foams in 1981 totaled 1.15 billion lb, a decrease of 3.4% from 1980. 1980 had been down 13.5% from the peak year of 1979, when demand for flexible foams totaled 1.38 billion lb.

The drop for flexible foam was led on a percentage basis by small-volume packaging applications, which fell 10.3% in 1981 (to 26 million lb) from 1980.

The largest uses of flexible foams had smaller percentage drops. Furniture applications, the biggest, fell 3.0% to 479 million lb last year. And use of flexible foams in the transportation industry dropped 4.2% to 277 million lb in 1981 from the year before.

Demand for rigid polyurethane foams, according to the survey, increased 3.1% in 1981 to 561 million lb, thus doing much better than flexible foams. In 1981, consumption of rigid foams had dropped 4.1% from 567 million lb in 1979. The biggest use of rigid foams, construction, increased 0.6% in 1981 to 321 million lb. This was due partly to the strong commercial construction sector.

Additionally, the survey shows, the percentage of material spending for insulation in construction, appliances, and other markets continues to increase as builders and manufacturers strive to increase the energy efficiency of these units.

In the microcellular and noncellular area of polyurethanes, the reaction-injection-molding market was the star performer, increasing 37.9% (to 80 million lb) last year from 1980. Two other markets in this category—cast elastomers and thermoplastics—fell 4.6% and 4.9% respectively, in 1981 from 1980.

Total consumption of microcellular and noncellular polyurethanes in 1981, excluding adhesive uses, increased 10.4% to 181 million lb.

For 1982, according to the survey, consumption of polyurethanes essentially will mirror that of 1981. Although 1981 began strong and finished weak, Mobay believes that 1982 will end on an upward trend. Other urethane chemical companies agree with this assessment. However, they estimate that total consumption in 1982 will be down 5 to 10%, whereas Mobay says that consumption this year will be about the same as that for 1981.

Mobay says that over the next five years, growth of polyurethanes will be good. Flexible foam markets are relatively mature and will grow at about the same rate or slightly faster than gross national product. Rigid foam markets will grow well above that for GNP, but not so fast as they did in the 1970s, when growth was about 15% annually. Mobay says the market is beginning to mature so that 8 to 10% growth is expected.

Use of reaction-injection-molding polyurethane, according to Mobay, will grow much more rapidly. Since it is a much smaller base, however, RIM polyurethane will not account for so much volume increase as some of the slower growing, but larger-volume markets. □

Flexible foam volume is twice that of rigid foam, but has slower growth

Millions of lb	1981	1980	1979	1978	1977	1976
FLEXIBLE POLYURETHANE FOAM	**1149**	**1189**	**1375**	**1349**	**1249**	**1186**
Furniture	479	494	533	518	480	476
Transportation	277	289	390	392	360	344
Bedding	170	173	195	199	184	175
Carpet underlay	157	161	185	167	150	136
Textile	27	30	32	32	30	14
Packaging	26	29	26	26	25	19
Miscellaneous	13	13	14	15	20	22
RIGID POLYURETHANE FOAM	**561**	**544**	**567**	**492**	**417**	**362**
Construction	321	319	316	263	197	147
Tanks and pipes	42	36	44	42	39	38
Appliances	88	84	81	72	70	66
Transportation	22	24	39	45	42	40
Decorative	4	5	6	6	6	6
Marine flotation	11	14	16	13	12	14
Packaging	44	40	34	25	20	16
Miscellaneous	29	22	31	26	31	35

Source: Mobay

NOTE

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Cover 1, p.1, 10-13, 15-16.

Chemical &
Engineering
NEWS

September 27, 1982

More scientific news from
ACS Kansas City meeting

/ A1250-1 9/27/82

Zeolite markets promise big new growth

Page 10

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Chemical & Engineering NEWS

Cover: One of many industrial uses for zeolites is as molecular sieves at natural gas processing plants. Photo courtesy of Davison Chemical division of W. R. Grace

2 Letters
3 Editors Page

Concentrates

8 Business
17 Government
21 Science/Technology

The Departments

33 Meeting Briefs
35 Books
42 Meetings
56 Newscripts

News of the Week

- ***National Academy of Sciences releases first of five volumes*** *of a study assessing the quality of Ph.D. programs that train scientists for research careers.* ***Page 4***
- ***Law suit by Monsanto against EPA*** *over release of herbicide's formulation finally settled satisfactorily.* ***Page 5***
- ***Allied Corp. may enter Bendix, Martin Marietta takeover fight;*** *if it occurs, merger would change Allied's focus from chemicals to aerospace and electronics.* ***Page 5***
- ***New fire-retardant mattresses*** *developed by Sealy over a four-year period now are on the market for hotels and motels.* ***Page 6***
- ***Du Pont reaches agreement*** *with Petro-Lewis Corp. to sell interests in 29 major oil and natural gas fields.* ***Page 6***

Business

- ***Demand for zeolites,*** *which had been tied to several specialty uses, is being spurred by detergent application.* ***Page 10***

International

- ***Canada's chemical industry*** *is troubled by a myriad of ills.* ***Page 16***

Government

- ***Economic goals are sound but are proving hard to achieve,*** *concludes an ACS symposium on Reaganomics.* ***Page 18***
- ***U.S. refusal to discuss militarization*** *of outer space angers developing countries at UN space conference.* ***Page 20***

Science

- ***From the ACS meeting:*** *structure of mutagen that is implicated in human colon cancer is determined; novel inorganic ring systems spark interest; tetrazine dimers studied spectroscopically; groundwater chemistry affects plutonium leaching; lanthanide-sensitized luminescence shows its usefulness in organic analysis.* ***Page 22***

Education

- ***Lab safety gets a boost*** *as U.S. schools begin efforts to identify and remove hazardous chemicals from classrooms and storage areas.* ***Page 27***

Technology

- ***From Kansas City meeting comes news*** *of remote sensing systems using optical fibers and lasers; oil recovery hampered by the windfall profits tax; and evaluations of C_1 chemistry processes.* ***Page 28***

ACS News

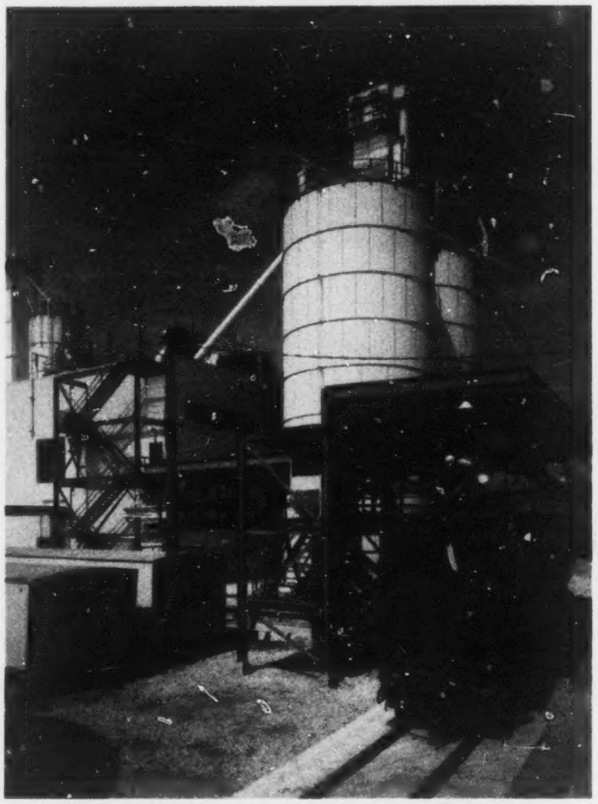
- ***Variety of activities*** *are revealed in photographs of Kansas City meeting.* ***Page 38***
- ***ACS offers employment aids*** *for unemployed members and proposes new activities to strengthen existing programs.* ***Page 40***

Detergents shift focus of zeolites market

Patricia L. Layman
C&EN, New York

For zeolites, the business always has been specialties—specialty applications as adsorbents and desiccants, as key ingredients in cracking catalysts, as molecular sieves. Growth was steady, if not always spectacular, for a business that was nearly 60 million lb in 1975 and that had prospects for growth to 75 million lb in 1980.

Well, that part of it happened. But while the market for zeolites—naturally occurring or synthetic aluminosilicates—was going along its ordered way, a new use sprang up that has overwhelmed the business—detergent zeolites. From out of the blue, zeolites for use as detergent builders have gained a market of probably close to 300 million lb this year. New suppliers have entered the picture, and established producers of zeolites have watched the detergent business by and large pass them by. The actual—and potential—volumes are attractive enough, but that doesn't much soothe the hurt that the prices for the detergent zeolites are much less, sometimes only one tenth, those producers can obtain for specialty products.



PQ Corp.'s new Kansas City, Kan., zeolites plant

But then, that's what has enabled the detergent market to grow—lower prices. From a start as molecular sieving agents, zeolites have always carried substantial price tags. Union Carbide, which developed the technology and held many of the early patents, had the field pretty much locked up. It had licensed only one other producer in the U.S., W. R. Grace's Davison Chemical unit, to produce the materials.

By the mid-1970s, however, the Carbide patents were expiring, and the major detergent makers were focusing on the aluminosilicate materials. Detergent makers were fighting the great phosphates fight: Phosphate builders, specifically sodium tripolyphosphate, were under attack by environmentalists who charged that the phosphates contributed to eutrophication of lakes and streams. Some states and regions banned phosphates as builders, and in other areas, detergent makers found it politic to at least lower the overall phosphate content in the formulation.

But what to replace the phosphates with? The first potential candidate—the trisodium salt of nitrilotriacetic acid—appeared to have health questions that needed answering. So the soapers turned to zeolites as sequestrants and ion exchangers that could help surfactants in a formulation overcome hard-water ions.

There was a specific need, however, for a price at least competitive with phosphates. And it wasn't until the patents on zeolites expired that that appeared possible. Naturally occurring, mined zeolites, of course, are available for as little as 10 cents per lb, but those materials don't offer the same attributes—purity of color, predictable performance, and so on—that a large-volume consumer application demands. Henkel in Europe and Procter & Gamble began working with potential suppliers of zeolites, and the way it has settled out, Ethyl Corp. is now by far the largest supplier of zeolites in the U.S. Ethyl's plant came on stream at Pasadena, Tex., in the late 1970s. And PQ Corp. is getting into the business, with the zeolite plant it just brought on stream this month at Kansas City, Kan. Meanwhile, such early suppliers of zeolites as Union Carbide, Davison, and J. M. Huber have seen the detergent market basically pass them by, and they are working to get back into contention.

For PQ and Ethyl, the business has been one of building on corporate strengths. For example, explains PQ zeolite venture manager Howard Sherry, Zeolite A, the most commonly used detergent zeolite, is two thirds sodium silicate, and PQ is the largest maker of that silicate. PQ, which has long marketed silicates to the detergent and soap industry, has witnessed its customers lately back-integrating into the material. "That meant we had to think about forward integrating, just for protection," says Sherry. "We had to look into making the products that use sodium silicate."

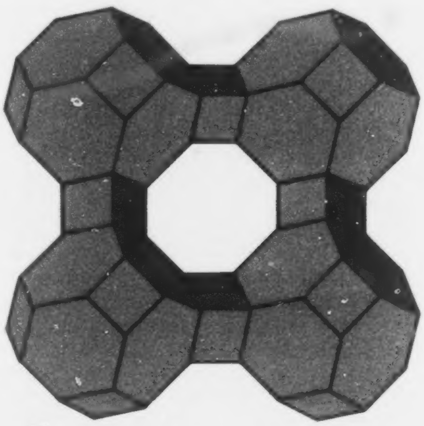
PQ also had to look into a material that was causing a serious dip in silicate use in detergents: from a high level of 7 to 10% in a detergent blend, to only 2 to 5% in formulations also containing zeolites. And there probably was some drive to upgrade its product line, with value-added technology for its sodium silicate.

Similarly, Ethyl was working off its strengths on the aluminum side. The company had done some R&D work on zeolites when the business began opening, using its know-how in metal chemistry derived from aluminum alkyls and antiknock compounds. "When the detergent industry became interested, it was very logical for us to seek to become a supplier," points out Fred R. Hogeman, marketing manager for alcohols and builders at Ethyl.

With a price of 28 to 30 cents per lb, zeolites are competitive with phosphates, which can run more than 35 cents per lb. That's true, marketers say, even given slightly poorer performance; for their cost, phosphates can't be beat as general, all-around sequestrants, especially for both calcium and magnesium ions, the commonest hard-water ions. Zeolites neatly remove calcium, but are less effective on magnesium—thereby requiring a cobuilder. That cobuilder can be phosphates, or even NTA, as it is being revived as a builder. In fact, some marketers believe that the revival of NTA will help the zeolites business. Zeolites are ideal low-cost ingredients to blend with and buffer the high cost of NTA, they say.

P&G has begun using zeolites in products for some of the regions it sells into, especially those in which phosphates are banned. And other, smaller detergent makers are turning to the materials, too. One problem potentially limiting widespread use is the patent question. P&G filed use-patent applications for detergents some seven years ago. However, those applications still are pending. If the patents are issued, "it would preclude any major use of zeolites by anybody else," says one detergent supplier. But the assumption seems to be that if the patent hasn't been issued in all this time, it never will—and the market will be wide open.

That, in turn, could boost con-



Controlled pore size is key to zeolite performance

Zeolites are crystalline aluminosilicates. The key to their activity is that the anhydrous crystal has a large, regular pore structure that lends itself to adsorption or catalysis.

Moreover, because of their chemical structure, zeolites function efficiently as molecular sieves to sort out molecules, and as ion-exchangers. The crystalline structure has a negative charge from the AlO_2 framework in the crystal. That requires a cation of some sort to neutralize the compound. And it's the cation that controls selectivity.

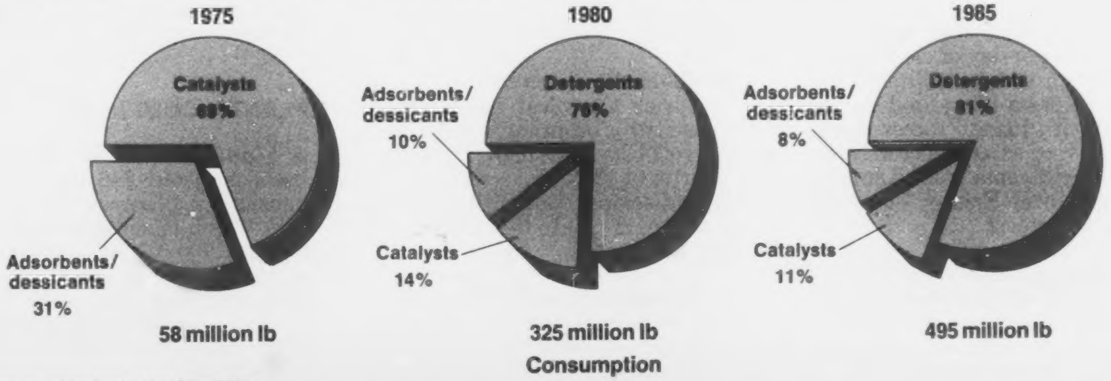
For example, the parent compound of the Type A zeolite, the most widely used, is the sodium compound, $Na_{12}[(AlO_2)_{12}(SiO_2)_{12}]xH_2O$, otherwise known as Type 4A. The sodium cations in the crystals partially block the pore openings, limiting the opening to about 4 Å.

The type 3A zeolite replaces the sodium cations with potassium. The potassium ion is larger, so blocks more of the pore, and the effective opening is roughly 3 Å. Correspondingly, for Type 5A zeolites, calcium ions replace the sodium. The ionic radii of the calcium +2 and sodium +1 ions are roughly the same, but because only half the number of calcium ions are required to balance the compound, more of the pore openings are unblocked. The effective opening is nearly 5 Å.

Other alumino-silicate-cation ratios can tailor the crystalline pore openings even further, making it possible to fine tune separations.

Synthetic zeolites basically have been an attempt to replicate and improve upon natural zeolites, found in large deposits in the western U.S. Much of the improvement comes in reproducibility, eliminating much of the chance aspect found in naturally occurring product. Because the materials are such excellent ion-exchange agents, they tend to take up whatever cations are in the local groundwater—magnesium, calcium, iron, barium, or more exotic ions such as strontium.

Detergents have come from nowhere to dominate U.S. zeolites market



Source: Oxenham Technology Associates

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sumption even more than present levels in detergents—a level now approaching nearly 80% of the entire zeolites business. "When detergents get involved, they require such large volumes that that application quite frequently eclipses the volume for other applications," notes one producer.

Once beyond the sphere of laundry detergents, however, zeolites are solidly a specialty business. Uses are relatively low volume and high priced (anywhere from five to 10 times those of detergent-grade zeolites). And significant amounts of technical service and development are demanded of suppliers. It also is, ironically, the older business, going back to the 1940s and Union Carbide and its Linde unit, that developed molecular sieves—a name Linde coined—for air separation. The zeolites adsorb nitrogen, enabling production of an oxygen-rich stream from compressed air.

This adsorption application also has been joined by desiccant applications, especially for natural gas transportation, taking out water or contaminants such as carbon dioxide and sulfur compounds. That's especially important, marketers say, for cryogenic gas separation, when the gas is chilled to remove compounds heavier than ethane. Contaminant moisture would freeze and wind up on the heat exchangers, fouling the procedure.

Marketers say the outlook continues to be promising for such applications. Already important as materials to purify the feedstock in conventional polypropylene and polyethylene processes, zeolites are used in low-pressure linear polyethylene processing in which they purify the feedstock gas coming in so contaminants won't poison the catalysts used in the processes.

And zeolites, functioning as molecular sieves, get another boost from the detergent field in addition to that of builders. They separate iso- from normal-paraffins, for linear paraffin feedstocks for surfactants.

Other uses have settled in, too. The increasing popularity, for example, of twin-pane insulating window glass has meant an increasing demand for zeolite desiccants to keep the air space between the panes free from moisture vapor building up from the sealants used to form the panels.

Not all of the applications that bright thinkers come up with work out, of course. One technical development specialist relishes recounting one attempted use, for example, as a drying aid in hair curlers. "That was back in the days before blow-dryers," he says. "The inventor wanted to put desiccants into the curler, to dry the hair faster." The product "flopped," he adds.

Other applications in this segment of the market offer more promise: as the basis for a kind of solar heat storage battery; for reversible adsorption and desorption; as carriers for chemical reactions, releasing a chemical, for example, when water hits the compound and carrier; and as a method of concentrating hydrogen for potential fuel use.

One potential application, as an animal feed additive, even has the promise of reaching commodity proportions. Researchers who originally had tried adding zeolites to chicken feed in an in-situ attempt to remove ammonia from manure to hold down odor, found that, instead, the plus was an improved efficiency in feed utilization, allowing a faster weight gain.

Many of the suggested uses, however, still are what one marketer calls "weird little things." That, in part, has kept adsorption-desiccation the smallest segment of the zeolites business—an estimated 10% of total

CHECKOFF

NEW PLANTS

■ **Fluorocarbons**—Halocarbon Products Corp. has begun construction of plant in Aiken County, South Carolina, to make both trifluoroacetic acid and trifluoroethanol; completion is scheduled for second-half 1983. Cost and capacities were not disclosed.

■ **Industrial gases**—Airco Industrial Gases will build plant in Franklin, Ky., with capacity of 180 tons per day of carbon dioxide at cost of $4 million. Completion is set for second-quarter 1983 with Plant Process Equipment Inc. as contractor. Feedstock will come from Kentucky Agricultural Energy Corp. fuel alcohol project.

At Sacramento, Calif., Airco will build $12 million plant to produce 260 tons per day of atmospheric gases separated from air; on-stream date is mid-1983.

At Deer Park, Tex., Liquid Air will build gaseous hydrogen unit at cost of more than $1 million to compress and purify hydrogen from by-product stream from Diamond Shamrock's nearby chlor-alkali plant.

■ **Isocyanates**—Rubicon Chemical subsidiary of ICI Americas will expand polymeric diphenylmethanediisocyanate (MDI) capacity at Geismer, La., 30%, bringing total to about 130 million lb by mid-1983. Engineering has been completed on previously announced 150 million-lb-per-year plant.

■ **Specialty resins**—B. F. Goodrich Chemical will double capacity for proprietary resins at Calvert City, Ky., plant by third quarter of 1983. No capacity has been disclosed for resins used as thickeners and flow control agents.

■ **Styrene**—Amoco Chemicals will modernize and expand unit 28% at Texas City, Tex., to make this aromatic monomer, bringing capacity to about 770 million lb per year. Lummus is contractor for engineering and procurement and Brown & Root is contractor for construction. Completion is set for August 1983.

■ **Titanium dioxide**—Du Pont will spend $2 million to expand capacity for rutile paper slurry grade material at Edge Moor, Del., plant 70% from an undisclosed amount. Expansion, to be completed in mid-1983, is to keep up with demand for RPS grade as paper makers continue to switch from anatase form of titanium dioxide.

PLANTS COMPLETED

■ **Alumina**—Martin Marietta has completed $46 million expansion of plant on St. Croix, U.S. Virgin Islands, bringing capacity to 700,000 tons per year for aluminum metal raw material. Company also seeks partners for further investment of $500 million to bring capacity to 1.5 million tons per year.

consumption in 1980, shrinking slightly to 8% by 1985, as detergents continue to grow and overwhelm the U.S. zeolites market. New uses are contributing to a growing market, however, as that segment of the U.S. market more than doubles from 1975 to 1985.

Doubling is more than can be said for the area of catalysts, primarily fluid-cracking catalysts. According to studies of the North American and European zeolites markets by Houston-based consultants Oxenham Technology Associates, U.S. demand for synthetic zeolites in catalysts is expected to reach 55 million lb in 1985, up from 40 million lb in 1975. Other estimates are somewhat higher, pegging present consumption at 60 million lb per year, but that may cover total world consumption. Growth through the early 1970s was more rapid; one estimate of consumption in the U.S. in 1974 was 21 million to 30 million lb.

Most of the catalyst market is in North America. By one recent count, Western Europe accounted for 47 catalytic cracking units, Latin America for 38, and the Middle East, 7—compared with the more than 150 in the U.S. and Canada.

To some extent, to talk about the market for zeolites in catalysts is misleading; the use of catalysts is far more significant than the estimates for zeolites would indicate. Unlike other zeolite applications, catalysts are a compounded product. Zeolites—the crystalline aluminosilicates—are embedded or formed in a matrix carrier clay in concentrations ranging anywhere from 5 to 40%. The matrix itself also is to some degree catalytically active.

There are two basic methods of preparation: gel-based zeolites, and clay-based zeolites. The gel process starts with sodium silicate and alumina, reacted to a gel matrix to which is added zeolite. The clay process starts with an aluminum-containing clay such as kaolin, which is treated to obtain both alumina and silicated clay, in a matrix to which zeolite is added. Typical starting zeolite is one known as Zeolite Y—approximate formula $Na_{58}[(Al_2O_3)_{58}(SiO_2)_{134}\text{-}(H_2O)_{250}]$. The zeolite then generally is heavily substituted, with various rare earth oxides—for example, lanthanum, neodymium, and cerium mixtures—replacing the Na_2O.

The degree of substitution, what's used to substitute, and how the substitution is effected are highly individual arts, and help explain why the field of catalysis is such a traditionally closed-mouthed area for the three major producers, Engelhard, Davison, and Filtrol.

Some people see that changing, however, particularly as the chemistry of zeolites becomes better understood. "These are regular structures, so chemists can more easily unravel what's really going on," says one researcher.

There also is more pressure being put on the industry to improve efficiency in performance. The petroleum industry had been putting a lot of time and effort on zeolite catalysts through the 1960s and into the early 1970s. But the oil embargo by the Organization of Petroleum-Exporting Countries' states added impetus to the work. The zeolite-containing catalysts dramatically increase cracking efficiency; normally reserved chemical engineers talk about "previously unheard of" improvements, or improvements on the order of "a millionfold."

In the wake of an economic slowdown, the demand for zeolites continues high. With demand for gasoline leveling off or down slightly, refineries generally are running at 60 to 65% of capacity. But catalytic crackers are running at 80 to 85% capacity.

■ **Antioxidants** — Ciba-Geigy has expanded capacity 50% from an unspecified capacity at McIntosh, Ala., to make proprietary family of hindered phenolic antioxidants. New capacity is expected to meet demands through 1985 for uses in plastics, coatings, fibers, and films.

■ **Butyl acrylate**—Badische has started up new unit in complex at Freeport, Tex., to make this widely used ester. Complex with expanded 2-ethylhexyl acrylate unit, acrylic acid unit due on stream in fourth quarter, and butyl acrylate unit will have total capacity of 350 million lb and cost $210 million.

■ **Calcium carbonate**—Pfizer minerals, pigments, and metals division has started up first phase of expansion at Adams, Mass., plant making coated grades of ultrafine precipitated calcium carbonates used as plastics and rubber additives. Uncoated products are scheduled to be made beginning in 1983.

■ **Carbon dioxide**—Liquid Carbonic subsidiary of Houston Natural Gas began operations in 400-ton-per-day unit to recover this gas, once vented from adjacent Agrico Chemical ammonia plant.

■ **Catalysts**—Engelhard's minerals and chemicals division has completed its third expansion since 1973 of its Attapulgus, Ga., plant making fluid catalytic cracking materials tailored to special needs of refiners.

■ **Enzymes**—Novo Biochemical Industries has completed $15 million expansion of Franklinton, N.C., plant, tripling its undisclosed original capacity for these materials, used in corn sweeteners, ethanol, detergents, and other products.

■ **Polyethylene**—Gulf Oil Chemicals has completed $35 million expansion of Orange, Tex., facilities, bringing capacity to make high-density polyethylene to 575 million lb per year from 420 million lb. Expansion brings company's polyolefins capacity to 1.9 billion lb, or about 9% of U.S. total capacity.

■ **Specialty chemicals**—Ritchem Co., Pleasantville, N.Y., has begun manufacture of Michler's ethyl ketone, derivative of tetramethyldiaminobenzophenone and Michler's methyl ketone, used in making certain dyes and in photographic and other industries.

■ **Sulfuric acid**—Texasgulf Inc. has started up 3100 ton-per-day unit at Lee Creek, N.C., to make this acid, used in making phosphoric acid for fertilizers. Monsanto Enviro-Chem Systems designed unit.

PLANT CLOSING

■ **Ammonia fertilizers**—Vistron subsidiary of Standard Oil (Ohio), has closed indefinitely its units at Lima, Ohio, making ammonia, urea, and carbon dioxide because of high gas cost and soft market for ammonia.

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- Cyclohexyl mercaptan
- n-Octyl mercaptan
- tert-Octyl mercaptan
- tert-Nonyl mercaptan
- n-Dodecyl mercaptan
- tert-Dodecyl mercaptan
- tert-Tetradecyl mercaptan
- tert-Hexadecyl mercaptan
- tert-Mixed mercaptans
  - (C_9, C_{12})
  - (C_{12}, C_{14}, C_{16})
- 2-Mercaptoethanol
- Benzyl mercaptan

Sulfides
- Ethylthioethanol
- Di-n-butyl sulfide
- Di-tert-butyl sulfide
- Ethylthioacetate
- Phenylthioethanol

Disulfides
- Di-tert-butyl disulfide
- Di-tert-dodecyl disulfide
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"If it's the most efficient way to do it, it makes sense to keep them running," says one marketer. Moreover, what the cracking units are processing is boosting the demand for zeolite catalysts, as well. "We were cracking fairly easy-to-crack feedstocks," says one producer, "but the crude slate has been changing to much more difficult-to-crack feeds" with a lot of metal and residue contamination. And increasing amounts of residual oil—normally burned as Bunker C fuel—are being diverted to catalytic crackers. That basically means refiners are adding more zeolite to cope with increased contamination, inactivity caused by elevated processing temperatures, and so on. Where once a barrel of oil would require roughly 0.15 lb of catalyst for processing, "today, it's not uncommon to go as high as 1 lb per barrel, in some specially designed units," says one marketer. And if the catalyst has an average of 15% zeolite, it's not a market to sneeze at.

From catalytic cracking to treating the petrochemical feedstock stream, zeolites benefit. In fact, as Paul Shimizu, general manager for silica products and adsorbents at Grace's Davison Chemical division puts it, "As long as the need for petrochemical feedstocks remains strong, the need for zeolites to treat them will remain strong."

And even the prospect of coal gasification sending in feedstocks to replace petrochemicals doesn't faze zeolite marketers. They're cheering for the success of the Texaco coal gasification process that Eastman Chemical is using in a plant it is building now at Kingsport, Tenn., and of such technology as the Purdue University method for converting ethanol and water mixtures into gasoline, which uses zeolite catalysts (C&EN, Aug. 9, page 6). "If coal gasification hits, that would be tremendous for us, in treating the process gases such as hydrogen," says Grace's Shimizu. "We can get the markets either way."

The entire field of zeolites is nothing to sneeze at. Companies already in the business and those getting in are betting that this steady little specialties market is just starting to take off, spurred by the detergents industry. That demand has brought about low-cost zeolites, which may help encourage the development of new applications. From there, it will be a challenge for producers to develop specialty forms and grades of zeolites to keep prices and profit margins as healthy as the market outlook is. □

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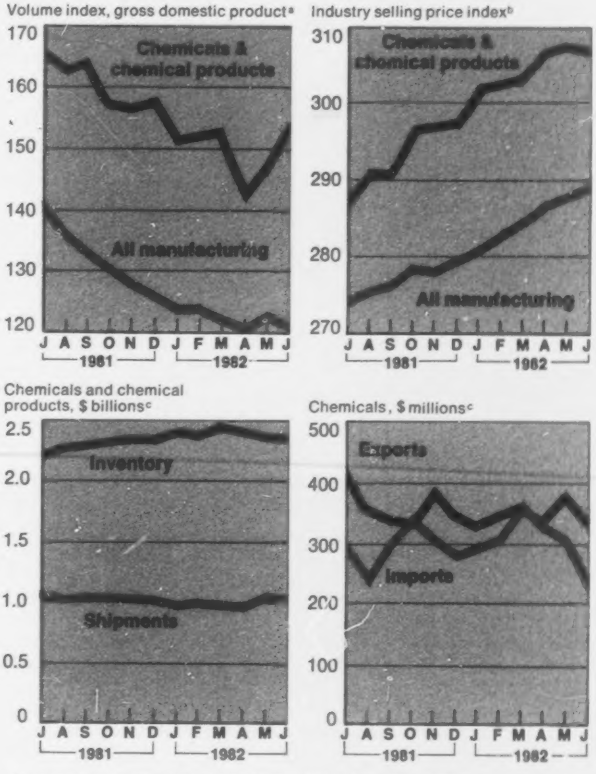
Canadian chemicals still in trouble



a Seasonally adjusted; 1971 = 100. **b** 1971 = 100. **c** Canadian dollars.
Source: Statistics Canada

The Canadian chemical industry's dream of becoming a major factor in the world petrochemical market may come true in time. But it will be delayed. For the moment, the industry, along with most other Canadian industries, is in big trouble.

The Canadian economy is in a shambles. Gross domestic product has been falling since the second quarter of last year. Unemployment has remained persistently high. Housing starts are down. Other industries that are important outlets for chemicals—pulp and paper, for instance—are retrenching.

Although there are signs that these problems may be starting to ease, inflation has been running at an average annual 10.5 to 11%. The Canadian dollar remains weak relative to the U.S. dollar.

All of this has had an obviously adverse impact on the Canadian chemical industry. And, to make matters worse, the worldwide petrochemical glut is making it increasingly difficult for the industry to export. Canadian chemical exports declined in the second half of last year compared to the first half, and declined again in the first half of this year.

With the market so shabby, however, chemical imports also have dropped off. As a result, the chemical industry has been able to maintain its favorable balance of trade surplus in chemicals.

The prolonged Canadian and world recession has cut into sales of most Canadian chemical companies. And, along with lower sales volume has come a bath of red ink as far as profits are concerned.

As a result, Canadian chemical companies are doing all they can to pare expenses and to conserve cash flow. The most startling example of cash-conservation efforts has been Union Carbide Canada's recent decision to bow out of the $300 million (Canadian) ethylene glycol plant it was building in Prentiss, Alta. The U.S. parent company, Union Carbide Corp., will take over financial responsibility of the project from its Canadian subsidiary, which suffered a net loss of $5.7 million during the first half of the year.

Many Canadian chemical companies, Union Carbide Canada included, put much of the blame for their predicament squarely on the government. Weak market demand had made it impossible for them to increase prices to profitable levels. Yet, government energy policies have sent feedstock costs soaring. This is especially true of oil-based feedstocks.

Whatever the reasons, the results are obvious. Six-month production statistics paint a discouraging picture. Everything is down, down, down—basic organics, plastics, and inorganics alike.

Earlier this month, Prime Minister Pierre Elliott Trudeau played musical chairs with four of his cabinet ministers. The energy minister became the finance minister, the finance minister became the minister of external affairs, and so on. These moves are considered a sign of just how serious the government thinks the economic situation is. But Canadian chemical executives would rather see the government do more about it than just play musical chairs.

Earl Anderson, New York

Chemical output: a dismal performance

Production, thousands of metric tons	1981	First-half 1982	First-half 1981	% change
ORGANICS				
Ethylene	1330	457	662	−31.0%
Propylene	677	287	328	−12.5
Benzene	566	247	311	−20.6
Toluene	480	208	219	−5.0
Xylene	410	190	209	−9.1
PLASTICS				
Polyethylene, low density	451	201	209	−3.8
Polyethylene, high density	223	93	113	−17.7
INORGANICS				
Hydrochloric acid	186	67	92	−27.2
Nitric acid	861	385	430	−10.5
Phosphoric acid, 100% P_2O_5	744	314	406	−22.7
Sulfuric acid	4117	1839	2113	−13.0
Ammonia, anhydrous	2654	1267	1325	−4.4
Ammonium phosphate	1355	549	726	−24.4
Chlorine	1292	616	656	−6.1
Sodium hydroxide	1458	685	733	−6.5

Source: Statistics Canada

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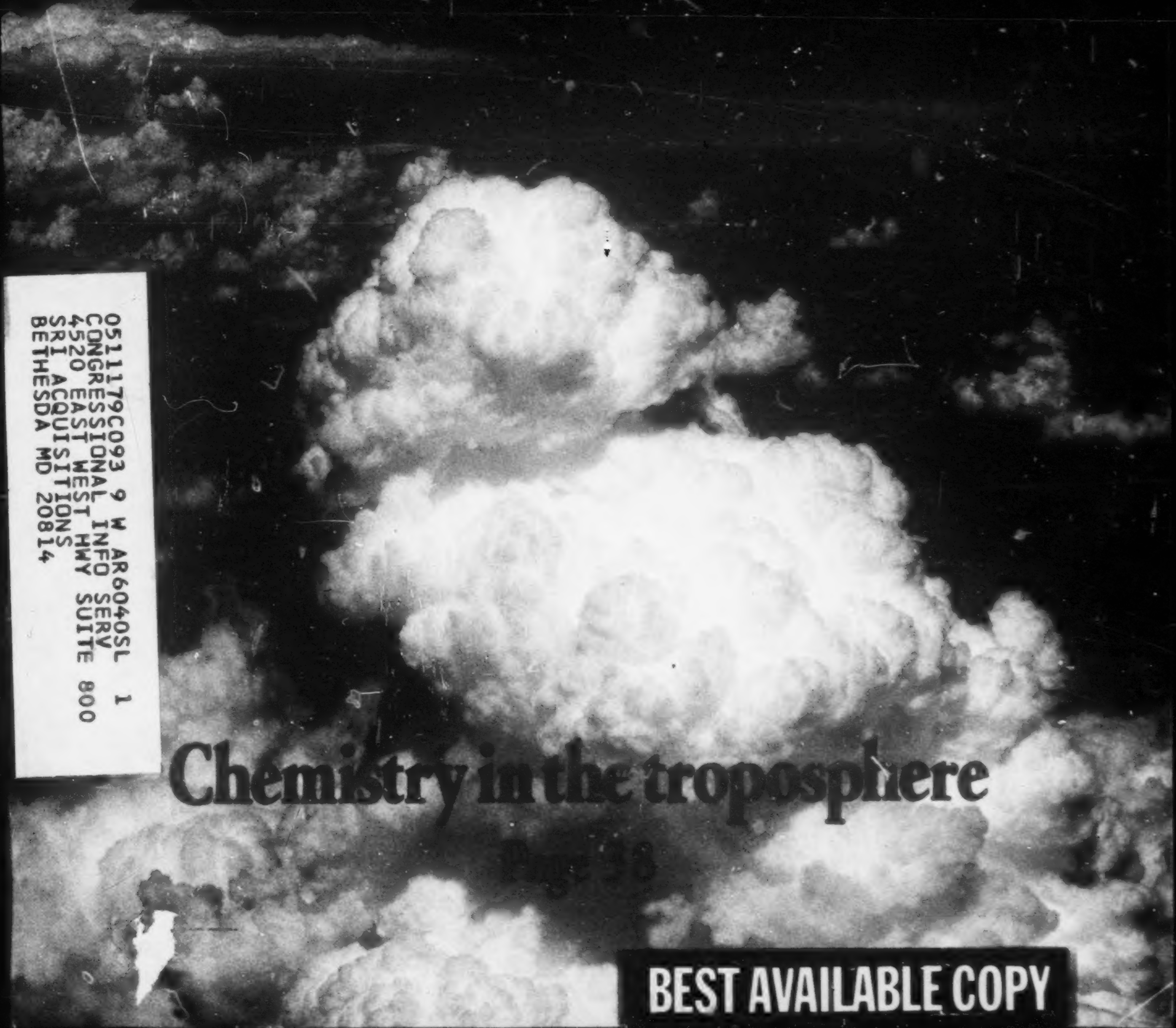

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Chemistry in the troposphere

Page 38

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October 4, 1982
Volume 60, Number 40
CENEAR 60 (40) 1–68
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Chemical & Engineering NEWS

Cover: Photo courtesy of Photofile Intl./A. J. Hartman

2 Letters
3 Editor's Page

Concentrates
7 Business
13 Government
17 Science/Technology

The Departments
55 Meetings
68 Newscripts

News of the Week

- ***Communication of most university research*** *should not be controlled, says NAS panel on science and national security.* ***Page 4***
- ***Existing laws are inadequate*** *to cope with small claims of toxic exposure, panel says; suggests alternatives.* ***Page 4***
- ***Allied's acquisition of Bendix*** *will make it a highly diversified company.* ***Page 5***
- ***Derailment of train*** *carrying chemicals causes evacuation of 3200.* ***Page 5***
- ***Monsanto abandons polyester staple*** *to concentrate on nylon fiber.* ***Page 6***
- ***American Cyanamid will lay off 75*** *research workers at Bound Brook, N.J.* ***Page 6***

Business

- ***Signs that the economy is recovering*** *has some analysts optimistic about a pickup in housing and automobiles.* ***Page 8***
- ***Union Carbide's reorganization*** *poises two executives for top posts.* ***Page 9***

International

- ***Council of scientific unions*** *expands its membership and programs.* ***Page 10***

Government

- ***Merits of patents vs. trade secrets,*** *aspects of risk assessment of chemicals are probed at ACS meeting sessions.* ***Page 14***

Science

- ***From the Kansas City meeting:*** *progress in nonlinear optical materials, science implications of "information age," new rationale for primordial gene code, laser for probing semiconductors, intercalated graphites developments, tobacco flavor findings, microbore HPLC-FTIR in mixture analyses, grain contamination problem, polymer coating for boosting electrode selectivity, synthesis of tsetse fly pheromone, polymers for inhibiting frost damage in crops.* ***Page 18***

Technology

- ***More from Kansas City:*** *current status of U.S. coal liquefaction effort; overview of research on anchored catalysts.* ***Page 31***

Education

- ***Chemical research at undergraduate level*** *deemed important in educational process, but funds are scarce.* ***Page 36***

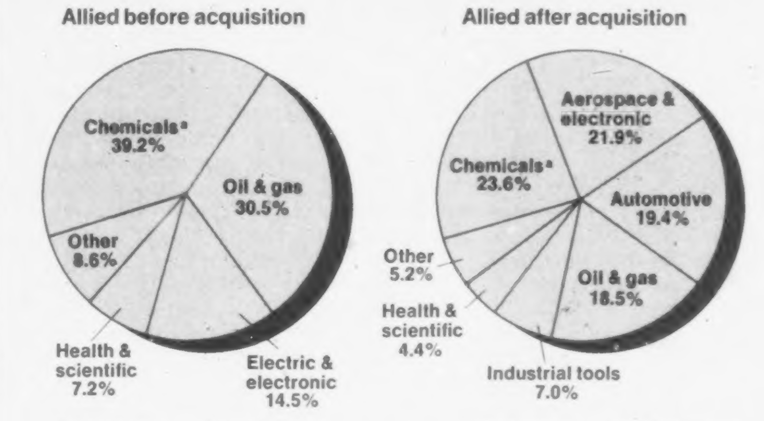
Special Report

Chemistry in the troposphere *probed using advanced techniques; some atmospheric trace gases and aerosols found to have major environmental impact.* ***Page 38***

ACS News

- ***Plan to charge emeritus members for C&EN defeated*** *by council.* ***Page 53***

Allied becomes conglomerate with acquisition of Bendix



Total sales = $6.77 billion[b] **Total sales = $11.20 billion[c]**

[a] Includes fibers and plastics. [b] Based on Allied's 1981 results, including full-year results for Fisher Scientific, acquired by Allied in fourth-quarter 1981. [c] Based on 1981 results for Allied and Bendix, including full-year results for Fisher Scientific, acquired by Allied in fourth-quarter 1981.

securities in the merger. Each Bendix share will be valued at about $85.

Allied says that William M. Agee, chairman of Bendix, will continue as Bendix chairman and chief executive officer and will become president and a director of Allied. Two other Bendix executives will become Allied directors. Bendix will be operated as a separate subsidiary of Allied and will remain headquartered in Southfield, Mich. □

Monsanto bows out of polyester staple

Strike Monsanto from the dwindling list of U.S. polyester staple fiber producers. The company is shutting its polyester staple plant at Decatur, Ala., which has a capacity of about 120 million lb per year.

This is the last of Monsanto's interests in polyester fiber. Early in 1981, it sold to Celanese a 70 million lb-per-year polyester filament plant in Fayetteville, N.C. At the same time, it closed another plant, of similar capacity, at Sand Mountain, Ala.

The action is, in part, an indication of the continuing problems facing the polyester fiber business, both for staple and filament. This summer, for example, Celanese cut its capacity for polyester filament, slashing maximum output from about 450 million lb per year to 250 million lb (C&EN, May 31, page 7).

Monsanto has decided, instead, to concentrate on its nylon fiber business, in which it is a far more significant factor, probably the second largest producer in the U.S. At the same time Monsanto announced the exit from polyester, it disclosed plans to convert two thirds of its nylon flat feeder yarn capacity to partially oriented nylon yarn at Pensacola, Fla. This modification, which will not change the capacity total, is expected to be completed by mid-1984.

"This project will enable Monsanto to keep pace with our downstream customers, the throwsters who are investing in advanced-generation draw texturing equipment, by providing a fiber that they can use on their new machinery," says Robert E. Burke, managing director of Monsanto Textiles Co.

Primary end uses for partially oriented nylon are women's hosiery, men's socks, and active wear. □

Monsanto still is one of biggest nylon producers . . .

	Capacity (millions of lb)
Du Pont	1375
Monsanto	560
Allied	455
Akzona	210
Badische	145
TOTAL	**2745**

. . . but in polyester, its exit leaves four majors

	Capacity (millions of lb)
Celanese	970
Du Pont	963
Eastman	450
American Hoechst	355
TOTAL	**2738**

Cyanamid to lay off 75 lab employees

Troubled by the state of the economy, more chemical producers have turned to layoffs of laboratory workers as part of their efforts to cut costs. The latest is American Cyanamid Co., which will shut down almost all research at its Bound Brook, N.J., site and fire 75 persons, most of them technical.

The biggest layoff of laboratory workers to date is at Celanese, which has let 172 people go at Summit, N.J., and Corpus Christi, Tex. Still other layoffs have occurred at Gulf Research & Development Co., a part of Gulf Oil.

American Cyanamid will consolidate all of its chemical research in Stamford, Conn., and eliminate 129 jobs at Bound Brook. Only 54 of these persons will be offered transfers within the company. Some process research will continue at Bound Brook on behalf of the firm's Lederle Laboratories subsidiary. Edward W. Cantrall, director of research for Cyanamid's chemical division, said the decision is part of a continuing program to improve profitability of the chemical business by concentrating on research programs that meet long-term objectives and eliminating those that do not. In addition to severance pay and other benefits, Cyanamid has offered outplacement assistance.

Similar desires to reduce efforts on mature products led Celanese to lay off 130 of the 560 salaried people at its corporate research center in Summit, N.J., and 42 out of 278 employees at the Celanese Chemical Co. technical center in Corpus Christi. The company also gave outplacement assistance as well as other benefits during August, when the layoff occurred.

Gulf Research & Development notified 60 of the 1500 people at its Harmarville, Pa., laboratory on Sept. 17 that their jobs would end effective Nov. 11. A company spokesman said the move was part of a program to streamline their efforts and reduce costs.

Though PPG laid off 200 people in its glass fiber division during September, only 10 of these were at the research center near Pittsburgh, says a company spokesman. The firm also closed a laboratory associated with the chemical division in Corpus Christi. PPG's glass division also has reduced employment about 20%, most of that gradually in 1982. □

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October 11, 1982

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Chemical plant capacity use stays low
Page 12

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Mid-term elections

The stake for science and business
Page 22

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ISSN 0009-2347

Chemical & Engineering NEWS

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Ted Charles

4 Letters

Concentrates

10 Business
21 Government
26 Science/Technology

The Departments

38 ACS News
40 People
52 Newscripts

News of the Week

- ***Industry will change greatly by 2000,*** *Dow Chemical Europe head says.* ***Page 6***
- ***Dow Chemical*** *to become third commercial producer of polycarbonates in U.S.* ***Page 6***
- ***Gulf Oil Chemicals restarts plant*** *shut down during extortion attempt.* ***Page 7***
- ***Nonanimal test*** *for cosmetic irritancy shows encouraging results.* ***Page 7***
- ***Funding for research programs*** *at NSF, NASA, and EPA has been set.* ***Page 8***
- ***Chemical capital spending*** *in 1982 drops again, Commerce survey finds.* ***Page 8***

Business

- ***Chemical plant capacity use still historically low;*** *operating rates are edging up, but shutdowns have cut capacity.* ***Page 12***
- ***Company formed to treat old, new chemical wastes*** *at Michigan site.* ***Page 16***

International

- ***Mexico's chemical industry is in serious slump,*** *a victim of the economy.* ***Page 17***
- ***Western Europe's petrochemicals and thermoplastics*** *do poorly.* ***Page 19***

Government

- ***Elections 1982:*** *Congressional key races are beginning to shape up.* ***Page 22***
- ***Science priorities*** *are the subject of a probe begun by the House Science & Technology Committee.* ***Page 25***

Science

- ***Element 109*** *produced in West Germany by cold-fusion technique.* ***Page 27***
- ***Gene regulation in higher animals*** *still a puzzle to scientists.* ***Page 28***
- ***Molten salt baths*** *cited as hazard after causing an explosion that demolished Berkeley lab.* ***Page 29***
- ***Electrocyclic reactions*** *produce polycyclic acids in nature.* ***Page 29***

Education

- ***Council for Chemical Research,*** *just two years old, surges ahead.* ***Page 31***
- ***Plan to ease engineering faculty shortage*** *urges cooperation among government, universities, and the private sector.* ***Page 32***

Technology

- ***Carbon dioxide recovered from flue gases*** *using new process could help meet increasing demand for carbon dioxide.* ***Page 33***

Books

- ***"The Warning: Accident at Three Mile Island"*** *by Gray and Rosen gives compelling account, but exaggerates risks.* ***Page 35***

BIG CHANGES IN CHEMICAL FIRMS BY 2000

By the year 2000, as many as 10 of today's top 30 chemical companies won't be around "as we currently know them," says Frank P. Popoff, president of Dow Chemical Europe. The survivors, he adds, will have been drastically restructured.

In a speech to members of the Chemical Manufacturers Association, given at CMA's meeting in Chicago, Popoff reminded his audience that the malaise now affecting the chemical industry worldwide has been a reality in Europe since mid-1980. Since then, "prices have been depressed and the economy has been in the grip of recession, with chemicals joining steel, textiles, transportation, autos, and construction as one of the 'sick industries' of Europe."

The problems are well known, Popoff says. Poor growth rates are forecast for the remainder of the decade. "Negative volume growth" has been a reality for numerous commodities last year and this year. "The overcapacity is enormous," the Dow executive observes. For example, Western Europe currently has about 16 million tons of ethylene capacity but only about 10.5 million tons of ethylene demand. The situation is similar for thermoplastics. At the same time, costs have continued to climb.

The role of governments in the chemical industry currently is receiving a great deal of attention, Popoff says. "Regrettably, this attention is fully warranted." Nationalization, either official or de facto, is commonplace.

Already, Popoff says, government enterprises have replaced the major oil companies as the leading threat to traditional chemical producers. "The motivations of governments in the chemical industry are a far cry from those of the oil companies," he contends. "They concern themselves with employment and foreign exchange management, rather than upgrading their crude."

By late 1980, the inevitability of structural change in the world's chemical process industries was evident, Popoff says. So, "well before the impact of our current problems, we in Dow Europe initiated a study in an attempt not only to look at inanimate factors such as growth rates, cost structures, processes, feedstock alternatives, and the like, but also to take a look at the number, character, and location of the firms who in the future would be producing the bulk of commodity chemicals. These firms would be the largest in terms of size—but not necessarily giants in terms of profitability.

Popoff: survivors will be restructured

"We determined that by the year 2000, as many as 10 of today's top 30 firms would not be around as we currently know them, by virtue of mergers, acquisitions, rationalization, and nationalization." Also, "instead of all the top 20 firms being in Western Europe and the U.S., 10 of the top 20 could be emerging elsewhere."

That study was "contentious" when it was made, but it seems less so each day, Popoff says. "The Japanese already have made the list. Canada and Saudi Arabia have investment programs that could propel them rapidly. New concerns are emerging as national enterprises, through raw material strengths and ambitions. Existing concerns are exiting through rationalization, nationalization, necessity, or decision to pursue other alternatives."

As to possible solutions to the problems, Popoff notes that, despite all efforts, "we seem to have only marginal impact on government policies, the price of oil and feedstocks, interest and foreign exchange rates, and the ability of industry and the consumer to finance demand." Thus, he concludes, "we are well advised to concentrate on those issues we can impact; specifically, product mix, customer mix, price, and restructuring."

Popoff lists the essential elements of the "rationalization" that he says the chemical industry must undertake to strengthen prices and restore profitability: "Shut down overcapacity. Restrict efforts to businesses where our technology allows for demand creation and cost reduction. Divest businesses that don't fit. Modify product and customer mix to emphasize demand growth opportunities. Long range, emphasize manufacturing, marketing, and, especially, research and development efforts that fit the new objectives."

This rationalization is taking place already, in hydrocarbons, heavy organics, chlor-alkali, and thermoplastics, Popoff says. But, he adds, it's not happening fast enough.

Popoff observes that U.S. chemical producers, threatened in the area of commodities, are "grasping at every opportunity in the area of specialties." In fact, he warns, "if all of us do all that we have said we will in the field of chemical specialties, the result—even in a field as broad as specialties—will be horrible overcapacity. However, if we make the right choice on our relative merits, then innovation can be rewarded and the 'me too' syndrome, so damaging to commodities, can at least be avoided in specialties." ☐

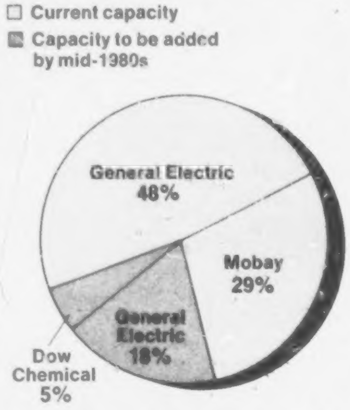
Dow plans to enter polycarbonate market

Dow Chemical's board of directors has given the go-ahead for the company to enter the polycarbonate market.

Dow has been operating a semicommercial plant to test the market, but the authorization by the board will permit the company to build a 30 million lb-per-year polycarbonate plant. It will be located at the company's Texas division in Freeport. The plant is scheduled to begin production in early 1985.

When the plant is started up, Dow

GE still will dominate polycarbonate capacity



Total capacity in mid-1980s = 555 million lb per year

Source: Industry estimates

will become only the third commercial U.S. producer of polycarbonates. General Electric and Mobay are the other two.

Dow, with its 30 million-lb plant, will be the smallest of the three. General Electric has a current estimated annual capacity of about 265 million lb; Mobay has an estimated capacity of about 160 million lb. However, between 25 million and 30 million lb of Mobay's capacity was closed earlier this year. A spokesman for Mobay says the shutdown is for an indefinite period, but this capacity could come back on stream if the market improves.

Apparently the market will have to improve if anyone is going to do very well. Current U.S. capacity totals about 400 million lb. However, Dow estimates that total U.S. consumption last year was only about 240 million lb. Dow says polycarbonate consumption is expected to grow about 7 to 8% per year.

At that rate, it will take some time before consumption catches up with current capacity, let alone what is scheduled to come on stream in the middle of the decade.

Besides Dow's 30 million lb slated for 1985, General Electric has a planned expansion of 100 million lb to its Montgomery, Ala., plant on the boards. This expansion originally was scheduled for 1985, too, but General Electric has delayed it for at least a year.

Industry observers say that exports of polycarbonate were about 50 million lb in 1981. Most of this went to Japan, almost all from General Electric.

Dow's plan seems to be to take some market share away from current producers, and also to develop some of its own specialty niches through developmental work. ☐

Gulf restarting plant after extortion attempt

Gulf Oil Chemicals expects to be well on the way toward a complete restarting of its bomb-threatened plant at Cedar Bayou, Tex., this week.

The plant was shut down in late September after a group attempted to extort $15 million from the company by placing bombs in the plant. Startup of the unit began on Oct. 5 and is expected to require about two weeks.

A Gulf Oil Chemicals spokeswoman confirmed that it cost $1.5 million to shut down and restart the plant and that losses ran about $300,000 for each day the plant didn't operate. Total costs for coping with the extortion attempt therefore will run between $4 million and $5 million.

The Cedar Bayou plant, largest of Gulf Oil Chemicals' plants, produces ethylene, propylene, and derivatives such as polyethylene, polypropylene, and alpha-olefins. Initial production of ethylene and propylene began in late 1963. Expansions to original capacity and addition of other products on the Cedar Bayou site, which covers more than 1000 acres, has increased employment to 1100.

Five of the 10 explosive devices threatened for the plant in letters to the company from the extortion group were found Sept. 30. Four were disarmed and the other exploded harmlessly. The remaining devices apparently were not put into place.

Employee safety was the paramount reason for shutting down the plant. After shutdown, only a small number of employees stayed at the plant doing security and maintenance work.

Lost production at the Cedar Bayou plant did not keep Gulf from meeting its contracts for sale of the various chemicals, according to an official. Inventories are judged sufficient to cover sales commitments along with product exchange agreements. ☐

Progress in nonanimal cosmetic irritancy test

Two scientists at Rockefeller University are making progress toward a nonanimal test for irritancy of cosmetics' ingredients. Their work could lead to a replacement for the Draize test used now.

Animal rights activists have objected to the Draize test, in which the substance tested is put into one eye of a live rabbit and the degree of irritation is judged by comparison with the other eye.

Biochemistry professors Ellen Borenfreund and Charles Shopsis of the university disclosed their findings to a New York Academy of Sciences conference on cellular systems for toxicity testing. The Rockefeller investigators are correlating literature results in the Draize test to either uptake of radioactive uridine or light microscopic observations in cell cultures. They use either a mouse fibroblast cell culture called 3T3 or a human liver cancer cell line called Hep G_2.

Compounds tested to date in order of increasing severity of irritation in the Draize test are methanol, propylene glycol, ethanol, isopropanol, tetrahydrofuryl alcohol, *tert*-butanol, allyl alcohol, 1-pentanol, and 1-octanol. The research is supported by a three-year, $750,000 grant from Revlon (C&EN, Jan. 5, 1981, page 21).

For tritiated uridine uptake, the biochemists measure either volume

In-vitro test for irritancy of cosmetics would replace rabbit eye testing

Chemical capacity use remains depressed

Plant operating rates edge up to 63% in chemicals and 69% in polymers; permanent shutdowns lower capacity 2% as output falls 19%

William F. Fallwell,
C&EN Washington; Bruce
F. Greek, C&EN Houston

Tricky as they are to follow, especially in a chaotic year like this one, plant use rates are enormously informative on the state of the industry's health. At present, they provide a high-resolution x-ray of a patient in pain.

With the usual generous help from experts all over the industry, who scarcely relish discussing the current scene, C&EN has put together its latest semiannual scan of capacity use, for mid-1982, in the most important U.S. basic chemicals and polymers. The results etch out somewhat the same stark pattern as six months ago but with some important differences.

Plant use is still shockingly, historically low. However, the management reaction hinted earlier this year now is in full swing. Companies are applying stiff medicine in the form of plant shutdowns. Although conservative in counting these as permanent, C&EN's tally still shows an overall drop in the industry's production capability, possibly the first since World War II. This decline accounts for nearly all the industry's slight uptick in capacity use since the beginning of the year.

Specifically, the key points emerging from the welter of data show:

- Nameplate capacity use in 32 basic chemicals has inched up to 63% from a revised 61% early in the year. However, plant use still is far below its 72% rate a year ago and the recent high point of 81% in mid-1979.
- Nameplate capacity use in 11 basic polymers has moved up similarly to 69% from 66% last winter. But the latest reading is still way down from 81% in mid-1981 and the last peak of 85% in early 1980.
- Effective capacity use also has climbed lately, to 69% in basic chemicals and 75% in polymers, after hit-

Huge gasifier is hoisted into place at Tennessee Eastman's chemicals from coal project in Kingsport, Tenn.

Plant use has pulled up slightly in plastics and synthetic fibers

	Third-quarter 1982			First-quarter 1982			Third-quarter 1981		
	Capacity	Capacity use		Capacity	Capacity use		Capacity	Capacity use	
Billions of lb per year	(nameplate)	Nameplate	Effective	(nameplate)	Nameplate	Effective	(nameplate)	Nameplate	Effective
Plastics									
Polyethylene, low density	9.3	76%	81%	9.7	71%	76%	9.0	84%	89%
Polyvinyl chloride	7.8	64	74	8.0	62	72	8.1	75	87
Polyethylene, high density	6.1	82	86	6.0	66	69	6.0	83	87
Polypropylene	5.1	61	68	5.1	67	74	5.1	80	89
Polystyrene[a]	5.3	60	71	5.4	53	62	5.7	60	71
AVERAGE		**69%**	**76%**		**64%**	**71%**		**76%**	**85%**
Synthetic fibers									
Filament yarn									
Polyester	1.6	76	81	1.8	74	79	1.8	93	99
Nylon	2.0	64	68	2.0	60	64	1.9	84	89
Olefin	0.99	60	64	0.99	64	68	0.94	69	73
Staple									
Polyester	2.8	62	66	2.8	77	82	2.7	97	103
Nylon	0.99	76	81	1.0	56	60	0.97	94	100
Acrylic	0.84	82	87	0.84	71	76	0.83	79	84
AVERAGE		**70%**	**75%**		**67%**	**72%**		**86%**	**91%**
OVERALL AVERAGE		**69%**	**75%**		**66%**	**71%**		**81%**	**88%**

[a] Between 5 and 10% of this capacity is shut down. **Sources:** Industry sources, Society of the Plastics Industry, Textile Economics Bureau, C&EN estimates

ting bottom at 66% and 71%, respectively, in the first quarter. Effective capacity, almost always less than nameplate, is maximum plant output estimated by industry experts after allowing for changes in product mix, corrosion, unplanned maintenance, and other influences.

- Behind the capacity use figures, production has stayed virtually flat in basic chemicals this year and for polymers has risen just 3% since winter. Over the past 12 months, production has fallen a depressing 19% in basic chemicals and 14% in polymers. Nameplate capacity has fallen 2% in both areas over the past six months. Compared to a year ago, capacity also is down 2% in basic chemicals and level in polymers.

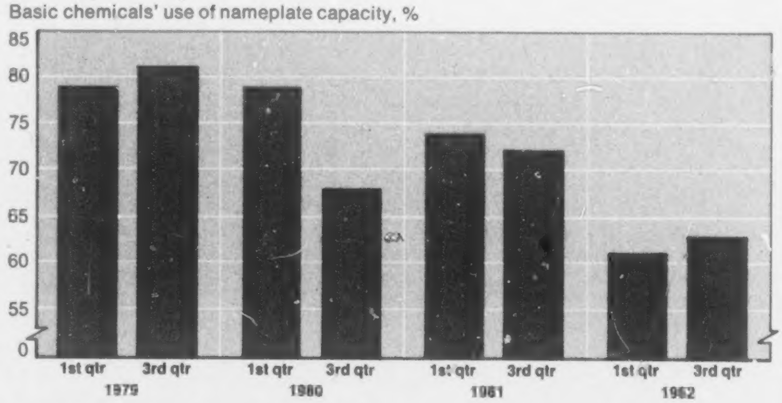
So, plant-use levels support the widespread industry belief that the recession has touched bottom but has not yet yielded to recovery. Although financial markets have improved greatly this summer and will keep right on gaining—in the opinion of analysts such as Du Pont's chief economist Charles B. Reeder—the state of real business is still poor.

Effective plant use in basic chemicals edges up to 69%

Billions of lb per year unless otherwise noted[a]	Third-quarter 1982			First-quarter 1982			Third-quarter 1981		
	Capacity (nameplate)	Capacity use		Capacity (nameplate)	Capacity use		Capacity (nameplate)	Capacity use	
		Nameplate	Effective		Nameplate	Effective		Nameplate	Effective
Petrochemicals—olefins and aromatics[b]									
Ethylene	39.0	61%	68%	39.7	56%	62%	41.0	65%	72%
Propylene (chemical and polymer)	23.5	55	61	23.5	43	47	23.5	59	66
Butadiene[c]	4.4	40	44	4.6	42	47	4.6	67	74
Benzene (bg)	2.4	48	53	2.5	42	47	2.7	67	74
***p*-Xylene**	4.9	60	63	4.9	61	64	5.6	64	67
Petrochemicals—C_1 derivatives									
Ammonia (mt)[d]	20.8	78	82	20.8	80	84	24.0[d]	80	84
Urea (mt)[d]	8.1	69	77	8.1	63	70	8.0	90	100
Methanol (bg)	1.6	76	84	1.5	72	80	1.4	83	92
Formaldehyde (37% solution)	8.9	47	49	8.9	51	54	8.9	65	68
Chlor-alkalies									
Chlorine (mt)	14.6	64	67	14.7	62	65	14.8	78	82
Caustic soda (mt)	15.6	61	64	15.6	59	62	15.5	75	79
Soda ash (mt)	10.9	73	77	10.4	76	80	10.0	83	87
Acids									
Sulfuric (mt)	59.6	49	52	59.4	54	57	58.5	74	78
Phosphoric (P_2O_5, mt)[e]	12.6	64	67	12.4	62	65	11.5	91	96
Industrial gases									
Oxygen **Nitrogen** } (total, liquid, ttd)	36 6	65	82	37.6	64	80	36.0	66	83
Carbon dioxide (ttd)	18.4	67	75	17.7	63	70	16.4	17	80
Mineral-based inorganics									
Sulfur (total, mlt)	15.8	53	—	15.7	61	—	16.0	68	—
Potash (mt)	2.7	74	—	2.7	84	—	2.9	76	—
Phosphorus (mt)	0.55	68	72	0.55	66	69	0.55	78	82
Plastics monomers									
Styrene	8.7	69	81	8.7	79	93	8.9	74	87
Vinyl chloride	10.0	68	76	9.6	50	56	9 7	70	77
Toluene diisocyanate	0.73	73	81	0.73	74	82	0.73	81	90
Fiber monomers									
DMT-PTA[f]	7.3	56	66	7.3	58	68	7.3	71	83
Ethylene oxide	6.8	67	74	6.8	68	76	6.8	72	80
Cyclohexane	3.1	37	39	3.1	33	35	3.4	59	62
Adhesives and coatings monomers									
Phenol[g]	3.6	61	68	4.0	56	62	4.0	67	74
Vinyl acetate	2.3	91	96	2.4	72	76	2.4	79	83
Pigments									
Carbon black	3.4	62	69	3.4	75	83	3.4	82	91
Titanium dioxide (mt)	1.0	61	72	1.0	53	62	1.0	82	96
Solvents									
Acetone[g]	3.3	53	59	3.6	59	66	3.6	58	65
Ethanol (mg)	240	75	79	270	50	53	270	56	59
Methylene chloride	0.83	63	70	0.83	54	60	0.83	64	71
AVERAGE		**63%**	**69%**		**61%**	**66%**		**72%**	**79%**

a bg = billions of gal, mt = millions of tons, tt = thousands of tons, ttd = thousands of tons per day, mlt = millions of long tons, mg = millions of gal. **b** About 25% of ethylene and lesser amounts of other capacity currently is shut down because of weak markets. **c** Total extraction capacity, which runs about 25% more than basic production capacity. **d** Some capacity, possibly 15%, shut down. **e** Includes both wet-process and furnace-process capacity. **f** Dimethyl terephthalate and purified terephthalic acid, not including acid converted to DMT. **g** Up to 10% of capacity currently shut down. **Sources:** Industry and government sources, C&EN estimates

Capacity use still is very low



Sources: Industry and government data, C&EN estimates

Roughly one third of the chemical industry's productive capacity is idle, and the low growth generally forecast for the 1980s would seem to put high-profit plant-use levels far in the distance.

But possibly not so far as the figures first indicate. The power of adjustment must not be underestimated. Company planners have shut down plants and chopped new investment aggressively in many products. The C&EN survey is slow to acknowledge many of these shutdowns. In other words, many plants now considered down temporarily, such as an estimated 8 billion lb per year in ethylene and 2 billion lb in conventional low-density polyethylene, may never restart.

And strange as it may sound after three no-growth years pockmarked with recession, the battered U.S. economy may yet give the chemical industry a fresh boost. If the current spurt in stock and bond prices on Wall Street is typical, it is predicting recovery in the manufacturing world in early 1983. Reeder at Du Pont doesn't think the early stages of this recovery will be vigorous, but he says emphatically that the last impediment to recovery, high interest rates, now is being overcome. Once recovery is under way, the pinched state of chemical inventories could lever production through several quarters of above-average growth.

Hence, C&EN plant-use surveys in 1983 could show a rapid change in capacity use. For the moment, however, the industry is grinding through an ugly year. Although the damage to plant use has been nearly universal, some product groups are in much worse shape than others.

One of the disaster zones is bedrock petrochemicals, where capacity use averages just over 50%. Industry analysts now believe that 2 billion lb per year of ethylene capacity is shut down for good, bringing the official total down to 39 billion lb. However, perhaps another 8 billion lb is out of production temporarily, and some of this may stay that way. That means the average use rate of plants in operation is roughly 75%, well above C&EN's listed average of 61%.

The C_1-based petrochemicals derived from natural gas also have been hit hard this year, averaging 68% capacity use, as markets have suffered in fertilizer and construction. In ammonia, for example, C&EN already had deleted 3.2 million tons per year of capacity by early 1982 because of permanent shutdowns, lowering the capacity total to 20.8 million tons. But industry sources now advise that many more plants, possibly 15%, have closed down in the current recession.

In methanol, a high-performing product in the late 1970s, the capacity situation is ominous. Plant use is down to 76% from 83% a year ago. That wouldn't be too bad by itself. But unfortunately, the product is in a capacity binge, one of the few in the chemical world at the moment. U.S. capacity is moving up steadily this year with more due shortly, and huge new capacity looms from Canada.

Derivatives of methanol and ammonia also are in trouble. Urea suddenly lost its export punch in late 1981, and capacity use here has plummeted from 90% in mid-1981, one of the best in the industry, to the present 69%. Plant closings have struck.

In the inorganic sphere, many crucial products have had similar fates. The chlor-alkali group entered 1982 with a massive problem in chlorine, now running at 64% of capacity.

C&EN's capacity-use indicator—the ground rules

Capacity use at chemical plants is difficult to measure and requires certain assumptions. These bring some order to the maze of variables affecting this critical indicator of the industry's health.

With the help of industry and government sources, C&EN measures capacity use as a percentage of both nameplate and effective maximums. Nameplate capacity is the official design capacity of plants. Effective capacity is the practical maximum after reductions for unplanned maintenance, corrosion problems, changes in product mix, and other influences. Although engineering companies and industry statistics groups try to make nameplate capacity data as "real" as possible, practical problems almost always reduce effective maximums to 85 to 95% of the official totals. For short periods, plants can run more than 100% of effective top capacity, but such a rate won't last more than a few months.

Capacity use is given over as much of a calendar quarter as production data permit, with no seasonal adjustment. The figures are for plants actually running. At present, some products such as ethylene, phenol, polystyrene, and urea have plants temporarily shut down because of weak markets. These plants still are included in capacity totals. The totals exclude new plants just starting up and old plants out of operation for long periods because of accidents. As much as possible, capacity figures stay current with expansions.

Capacity data don't take into account other temporary fluctuations for fuel and electric power interruptions, equipment failure, and feedstock scarcity or substitution. The feedstock variables have been important in the past few years in ethylene production, further reducing maximum output for several coproducts such as propylene, butadiene, and benzene.

Products in C&EN's capacity-use survey are the same as those in the Key Chemicals and Key Polymers series. These are the core products of the industry, the building blocks leading to downstream production of thousands of more specialized products.

Later compounded by a steep price drop in its formerly robust coproduct, caustic soda, the chlorine crisis has led to the first wave of many expected plant shutdowns. Capacity is receding steadily.

Soda ash, mined mostly in Wyoming, also is sagging in capacity use, falling to 73% in the new survey from 83% a year ago. Here, matters are made worse by large new capacity at Tenneco. Although this product may get another new round of investment by the mid-1980s, the capacity buildup is nearly over for the moment.

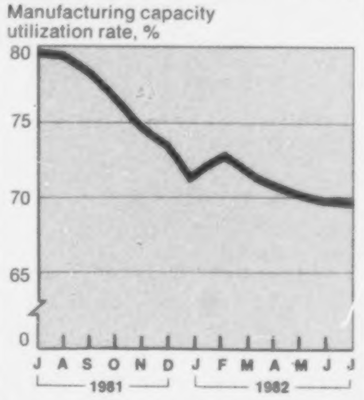
Two other large volume inorganics, sulfuric and phosphoric acids, have been tripped up by the big market dip in downstream phosphate fertilizer. Although capacity is moving up a bit in both acids, plant use has tumbled hard—from a lofty 91% a year ago to the present 64% in phosphoric and from 74% to a miserable 49% in sulfuric. Industry sources say as much as 25% of phosphoric acid capacity in its Florida heartland could be shut down.

In the mineral inorganics, sulfur has joined the recession in the past half year, finally hit by the sag in derivative sulfuric acid. Prices are falling after a long rise, and plant or mine use has slipped to 53% from 68% in mid-1981. Sulfur capacity still is rising, even though some mines are playing out, because desulfurizing capacity is rising at oil refineries.

To round out the basic inorganics, the industrial gases also have begun to reflect recessionary pressures. Their plant building spree of the past several years is beginning to look suspect as capacity use stays in the mid-60s in percentage. Still, these companies have set up a countercurrent of closings in old plants that has resulted in a rare capacity decline for merchant liquid oxygen and nitrogen. In carbon dioxide, vigorous investment continues in new plants. Capacity is well up this year, with capacity use fluctuating around 70%.

Downstream from these basic inorganics and organics, the large group of organic intermediates is not doing well. Plant use in starting materials for plastics, fibers, adhesives, and coatings is slightly below the industry average at 65%. New capacity addition practically has stopped, and capacity erosion has set in for styrene and phenol.

Capacity use has dropped sharply in all manufacturing



Source: Federal Reserve Board

Note, however, that vinyl acetate, with little new capacity in recent years and fairly stable production in the recession, outranks all other basic chemicals and polymers with a mid-1982 plant use rate of 91%. For the year, the product's analysts forecast a slightly lower average capacity use of 83%.

In the remaining basic chemicals, big-volume pigments are languishing at capacity use just over 60%. However, effective capacity in titanium dioxide is much less than nameplate, no more than 85%. And shutdown came after the C&EN survey period at NL Industries' plant at Sayreville, N.J.

Solvents similarly are having a poor year with average capacity use of 64% for acetone, ethanol, and methylene chloride. Although capacity has declined for synthetic ethanol, massive new capacity looms in fermentation ethanol, whose nameplate total has more than doubled in the past year to nearly 500 million gal per year. Some of this fermentation product has seeped into synthetic ethanol markets, worsening the glut.

In polymers downstream from organic intermediates, 1982 has been rough. In the big thermoplastics, production is up 5% from early in the year and capacity conservatively down 2%. Capacity use has picked up to 69% from 64% last winter. But the financial picture is gloomy, and more permanent plant closings are expected in low-density polyethylene and polyvinyl chloride.

Synthetic fibers have lost their bright prospects of a year ago, when capacity use outran all other major industry groups at 86%. Production has fallen a thumping 23%, but capacity is still up a bit. Capacity use is down to 70%. □

Company formed to clean up Lakeway site

Bofors Nobel has joined forces with two other companies, Zimpro and Chemical Waste Management, to establish a new firm, Environmental Systems Corp. (ESC). ESC's function will be to build and run a $20 million facility to treat chemical wastes—both old and new—from Bofors Nobel's Lakeway plant at Muskegon, Mich.

When Bofors bought Lakeway in 1977, it also bought some severe environmental problems. Soon it was discovered that wastes from the manufacture of a variety of chemicals—accumulated over the years and stored at the site—were being leached from landfills and were contaminating groundwaters.

There followed several years of litigation with Michigan authorities. From the negotiations came a 1981 agreement, the essence of which was that Bofors Nobel would clean up the old Lakeway mess and would make no new messes. According to Bofors Nobel, cleaning up the old mess will involve detoxifying about 175,000 cu yd of contaminated sludges and soils, and also intercepting and treating of more than 1 million gal of contaminated groundwater per day.

The ESC plant will use several waste treatment technologies. Heart of the system is a Zimpro-licensed PACT (powdered activated carbon treatment) unit that will detoxify contaminated groundwaters and also process aqueous wastes and scrubber effluents from the plant.

A multiple-hearth pyrolyzer will detoxify contaminated sludges and soils and biomass from the PACT unit and also will recover fuel values. Char from the pyrolyzer will go to secure landfills.

A wet air oxidation unit, also from Zimpro, will detoxify other waste streams and also will regenerate spent carbon from the PACT unit. Another unit will use proprietary technology to neutralize and detoxify waste acid streams.

Even after the site contamination is cleaned up (about nine years), the ESC facility won't be a white elephant, Bofors Nobel says. It will continue to treat wastes from ongoing manufacturing operations, and it also will permit the company to expand its specialty and custom chemical businesses. ESC also eventually may market its know-how to other companies facing similar problems. □

Slump hits Mexican chemical industry

Since late summer, chemical demand and production have slowed sharply owing to drastic turndown in the country's economy

Earl V. Anderson
C&EN, New York

Last month, Mexico's major chemical trade association abruptly canceled its annual forum shortly before it was scheduled to be held. "Too many companies couldn't afford to send delegates to the meeting," says Carlos Pani, director general of the Asociación Nacional de la Industria Quimica (ANIQ).

That just about says it all about the situation in which the Mexican chemical industry finds itself today. It, along with all other Mexican industries, is in trouble—big trouble. And only the most optimistic of industry officials believe that the situation stands a chance of improving by the middle of next year. Most others believe it will take much longer for the industry to pull itself back onto the fast-growth track that made it the talk of the international chemical community.

In fairness, the Mexican chemical industry is the victim of circumstances beyond its own control. The Mexican economy is shattered. Inflation is soaring above 100% per year. Unemployment is running about 25% and figures to get worse. Two devaluations have shrunk the value of the peso to a third of what it was early this year.

Mexico has the highest foreign debt of any country in the world—about $80 billion—and precious little foreign exchange to pay it or the interest on it. Controls have been imposed on this scarce foreign exchange. The government has clamped tight reins on imports. And last month, it nationalized the banks.

All of this is a bitter change for a country that, until this year, had been fueling an economic boom with its new-found oil wealth (and plenty of borrowed money).

Nowhere is the change more apparent than in Mexico's chemical industry. Through the first half of the year, chemical output in Mexico held up fairly well. But in late August and early September, it was as if the industry stepped out of one world and into another, much bleaker one. Since then, the nation's economy, chemical demand, and chemical production have started grinding to a halt.

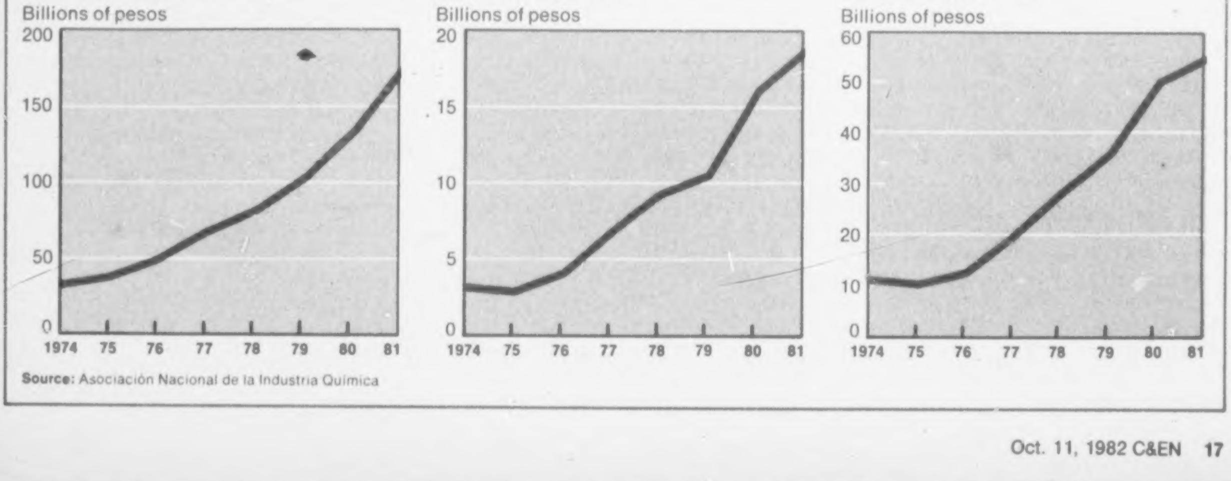
Petroleos Mexicanos (Pemex), the national oil giant that, by law, has a monopoly on basic petrochemicals production, expects to produce about 90% of its targeted 1982 output. At the start of the year, the goal was 11.4 million metric tons of basic petrochemicals. Actual production probably will be about 10.2 million metric tons. That's short of the goal, but still 11% higher than last year. More than actual demand, that increase reflects production from new plants that has replaced imports.

In the downstream, secondary petrochemical industry, where private domestic and foreign capital are permitted to participate, most companies are suffering badly. ANIQ's Pani says that chemical demand has held up better than demand in most other industrial segments, but that's not saying much.

With its import controls and lack of foreign exchange, one of the biggest dangers facing the Mexican government is the possibility of throttling badly needed industrial output that depends upon imports for raw materials. That same problem faces the chemical industry, which relies on imports, not only for many raw materials, but for such critical items as catalysts and plant equipment as well.

Even though chemicals rate a high priority (behind food) for imports in Mexico, there is very little foreign exchange available (even at the commercial rate of 70 pesos per dollar, much less at the preferred 50 pesos-per-dollar rate) with which to buy chemical imports. Certainly very few Mexican chemical companies themselves have foreign exchange available for foreign purchases.

The exceptions are those few companies that have a fair volume of


Despite increased production of Mexican chemicals . . .

. . . and higher exports of them . . .

. . . chemical imports continue to rise

Source: Asociación Nacional de la Industria Quimica

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LDPE, *p*-xylene dominate Mexico's petrochemical imports

	1981 imports of basic petrochemicals	
	$ Millions	Thousands of metric tons
Low-density polyethylene	$108.4	126
***p*-Xylene**	100.4	148
Styrene	64.4	88
Butadiene	45.8	54
Vinyl chloride	31.0	84
Dodecylbenzene	29.9	33
Ethylene oxide	25.7	31
Acrylonitrile	14.6	20
Propylene	11.7	24
Propylene tetramer	11.1	23
Benzene	11.0	21
Toluene	9.6	23
High-density polyethylene	8.6	10
Ethylene	7.3	15
Isopropyl alcohol	7.1	15
***o*-Xylene**	6.7	12
Xylenes	6.7	15
Ethylbenzene	6.3	11
Perchloroethylene	6.1	17
Cyclohexane	4.9	8
Acetaldehyde	3.7	6
Others	2.4	—
TOTAL	**$523.5**	—

Source: Petroleos Mexicanos

export business and are able to generate their own foreign exchange. Those companies are few indeed.

Mexico traditionally runs a sizable deficit in its chemical trade. Last year, for instance, it imported $2.2 billion worth of chemicals, but exports amounted to only $771 million. Obviously, there's little chance of the industry's generating enough foreign exchange to meet its own requirements.

Lars R. Christianson, director of Christianson S.A. de C.V. and newly elected president of ANIQ, cites the shortage of foreign exchange as one of the chemical industry's biggest bottlenecks. "I don't like them [the exchange controls]," he says, "but I can understand the reasons for them."

He believes that, because of the exchange controls and a stagnant Mexican economy, foreign exchange reserves likely will start building up again. Christianson thinks that, by mid-1983, there probably will be enough available to start importing more. And as imports become more available, they will rekindle the fire under Mexico's economic growth. He sees a real 2 to 3% growth in Mexican GNP starting in mid-1983. That's a far cry from the 7 to 8% increases over the past several years. But it would be a welcome change from stagnation and likely will be enough to allow the chemical industry to start whipping itself back into shape.

The irony is that, although a lack of chemical imports is a problem now, an excess of chemical imports will be the problem when and if Mexico sheds the economic shackles that now bind it.

Import substitution and self-sufficiency long have been goals of the Mexican chemical industry. When Pemex's huge petrochemical complex at La Cangrejera finally is completed next year, it will be able to supply some of the basic petrochemicals that have been imported.

Some, but far from all by a long shot.

In addition to producing all of Mexico's basic petrochemicals, Pemex also imports all of these products, reselling them to downstream customers, usually at a substantial loss. Last year, only two products (low-density polyethylene and *p*-xylene) accounted for 40% of Pemex's basic petrochemical import bill of $524 million. Add only three other products (styrene, butadiene, and vinyl chloride), and the share bounces up to 67%.

By the end of the year, La Cangrejera's 240,000 metric-ton-per-year *p*-xylene unit is expected to be operating. The 240,000-metric-ton low-density polyethylene plant probably will be on stream in the first quarter of 1983, followed shortly by the 150,000-metric-ton styrene unit.

These and other units at La Cangrejera (including a huge 500,000-metric-ton ethylene plant) will help ease Mexico's petrochemical import burden. But if the country's economy does rebound after next year, the output from La Cangrejera soon will be chewed up.

The next major Pemex petrochemical complex will be at Morelos, but the budget cuts are slowing down construction there. Originally due on stream in 1985, Morelos probably will be built now in two stages. The first stage will include the ethylene unit (another 500,000 tonner) and ethylene derivatives, particularly a 100,000-metric-ton high-density polyethylene plant. It may be 1987 before this first stage is complete. The second stage may not come on stream until two years later. This stage will focus on propylene and derivatives, including Mexico's first polypropylene plant.

Meanwhile, two other highly touted petrochemical projects have been put on the back burner. Officially, the Pemex projects at Laguna del Ostion and Dos Bocas have been postponed. How long is anybody's guess. Some say they will be scrapped.

Even if Pemex is able to eliminate basic petrochemical imports completely, which is unlikely, it won't completely solve the country's chemical import problem. These products account for only 23% of the chemical import total. Imports of other chemicals, by companies both inside and outside the industry, account for the rest. And substituting domestic production for these products will take a long time. □

La Cangrejera complex entirely on stream in 1983

Thousands of metric tons	Capacity
Acetaldehyde^a	100
Benzene^b	299
Cumene^c	40
Cyclohexane	120
Ethylbenzene	188
Ethylene^b	500
Ethylene oxide^c	100
Heavy aromatics	50
Heptane	11
Hexane	35
Low-density polyethylene	240
***m*- and *p*-Xylene^b**	370
Nitrogen^a	20
Oxygen^a	200
***o*-Xylene^b**	55
***p*-Xylene^b**	240
Styrene	150
Toluene^b	371

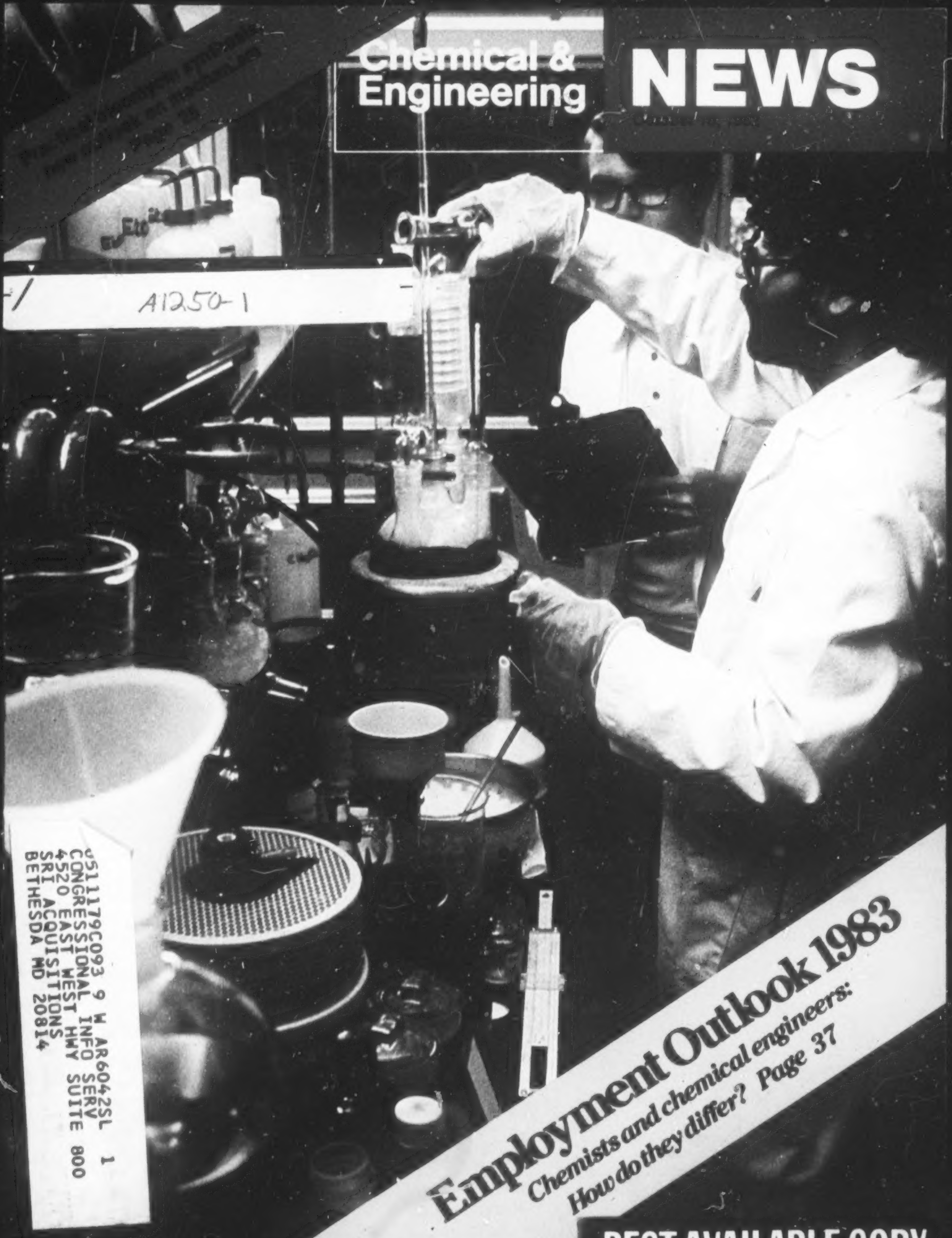
a On stream 1980. b Due on stream by end of 1982. c On stream 1981. **Source:** Petroleos Mexicanos

Morelos focus on ethylene, propylene, and derivatives

Thousands of metric tons per year	Capacity
Acetaldehyde	150
Acrylonitrile	50
Butadiene	100
Ethane	705
Ethylene	500
Ethylene oxide	200
High-density polyethylene	100
Hydrogen cyanide	7.5
Isopropyl alcohol	75
Methyl-*tert*-butyl ether	60
Nitrogen	60
Oxygen	350
Polypropylene	100
Propylene	377

Source: Petroleos Mexicanos

Chemical & Engineering NEWS



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Employment Outlook 1983

Chemists and chemical engineers: How do they differ? Page 37

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Chemical & Engineering NEWS

Cover: Research on new organic chemicals at Pfizer's Groton, Conn., facilities

4 Letters
5 Editor's Page

Concentrates
8 Business
19 Government
22 Science/Technology

The Departments
62 New Products
67 ACS News
74 People
76 Meetings
92 Books
94 Newscripts

News of the Week

- ***The tragic results*** *when cyanide was added to capsules of Johnson & Johnson's Tylenol likely will lead to packaging changes throughout the drug industry.* ***Page 6***
- ***The Nobel Prize*** *in Physiology or Medicine goes to Sune Bergström and Bengt Samuelsson of Sweden and John Vane of the U.K. for work on prostaglandins.* ***Page 6***
- ***The Reagan Administration's environmental policies*** *have been criticized in a second report issued by a consortium of 10 environmental groups.* ***Page 7***

Business

- ***Makers of fatty acids*** *suffer from the recession just as other chemical firms, but several producers are adding capacity in hopes of a better future.* ***Page 11***

International

- ***Canada will nearly double styrene capacity by 1985;*** *sees lucrative export markets in the U.S., Western Europe, Japan, Latin America, and the Far East.* ***Page 15***
- ***Canadian ammonia producers*** *see turnup by the mid-1980s despite slump in fertilizer use; low-cost natural gas feedstock gives them an advantage over U.S.* ***Page 16***
- ***Report on biotechnology*** *by Organization for Economic Cooperation & Development discusses possible R&D areas, economics, policy, and safety aspects.* ***Page 17***

Government

- ***Congress set 1983 appropriations*** *for NSF and NASA and for EPA's R&D programs in last-minute prerecess session.* ***Page 20***

Science

- ***Synthesis of the structure of bleomycin****, an anticancer antibiotic, gives some clues as to how it finds its way to cancer cells and destroys DNA.* ***Page 25***
- ***Designing a molecule*** *that binds to and cleaves double-helical DNA, researchers study how drugs bind to DNA.* ***Page 27***
- ***The Toxicology Data Bank****, undertaking of National Library of Medicine, contains data on known and potential toxicants compiled by peer-review groups.* ***Page 33***

1983 Employment Outlook

C&EN's annual survey *contrasts chemists and chemical engineers, provides data on demand and salaries for job seekers, career planning services.* ***Page 37***

ACS News

- ***ACS Western New York Section*** *criticizes society testimony before Senate committee concerning NSF.* ***Page 69***
- ***New CAS Search Service*** *conducts searches of its computer files for those who lack the equipment for doing so.* ***Page 69***

Fatty acid makers bullish on outlook

Fatty acids currently are struggling with slow markets and soft prices; upbeat on future, however, several producers are adding capacity

Patricia L. Layman
C&EN, New York

The fatty acid industry historically has been somewhat sheltered from economic downturns, because it is such a diverse business. Few end-use applications take more than 10% of the total, so if one end-use market is down, others usually hold up to keep the entire business from hurting too much.

But in the current recession, that hasn't happened. Over the past year, "business hasn't been all that good," as one marketer puts it.

On the other hand, the fatty acid business probably isn't in the grim category, because some producers do see some bright spots. And they see some even brighter spots for the future, when the economy turns around and some of the major end-use markets for the chemical industry—housing and automotive, for example—begin rebounding.

For now, fatty acid makers are trying to cope with slow markets and soft prices. Fatty acids is basically a mature business, growing at about the same rate as that of the gross national product, or perhaps even slightly less. Present consumption is probably about 1.65 billion lb annually, with little growth expected this year.

But with an eye on the future, several producers are expanding their operations. For example, Emery Industries, subsidiary of National Starch & Chemical, is in the middle of a $50 million expansion of its fatty acid production complex at Cincinnati. It expects the unit to go on stream late next year.

Witco's Humko Chemical division this spring launched an expansion of its Memphis plant to boost capacity for primary and secondary fatty amides about 50%. The expansion is scheduled for completion next spring.

And Glyco, a Greenwich, Conn.-based specialty chemicals producer, is nearing completion of a major expansion of its Painesville, Ohio, fatty acid operation, a move that it says will make it one of the largest producers of fatty acids in the U.S.

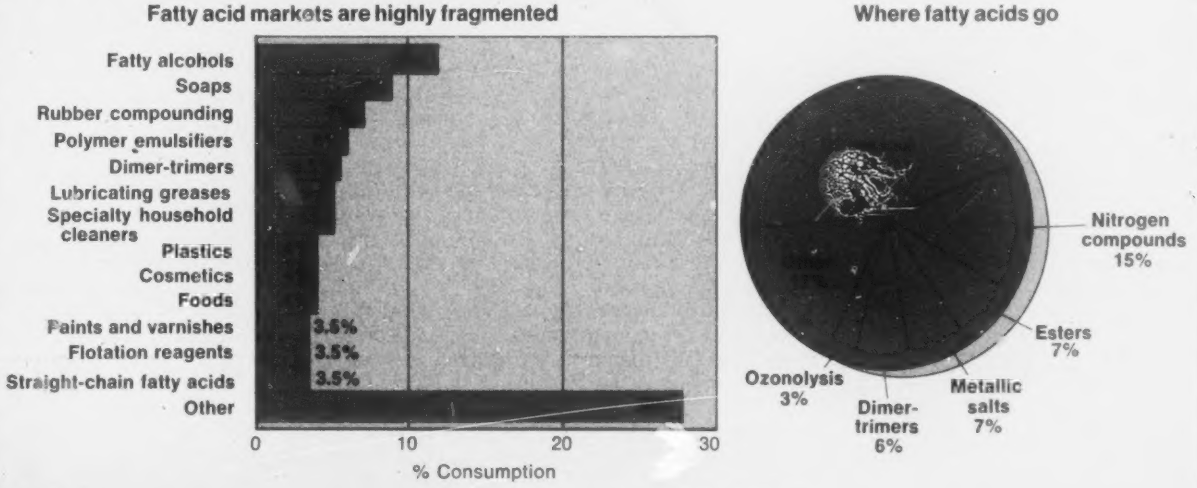
There is even a new player in the game—CasChem of Bayonne, N.J. CasChem was formed late last year to buy out NL Industries' fatty acid business, among others.

Conversely, the largest producer of fatty acids—Procter & Gamble—is standing pat with its 10 plants in the U.S. and Canada. P&G won't comment on how it views the current situation for fatty acids. However, it does point out that the situation often parallels that for general segments of the economy such as housing and automotive, which affect the fatty acids business.

Gulf Oil, which is reshuffling its chemical interests, is said to be trying to sell its Millmaster Onyx subsidiary, which includes the A. Gross fatty acids division, to concentrate on other chemical businesses. Ironically, the move to sell the subsidiary comes at the same time that A. Gross has embarked on a five-year marketing and sales plan that includes doubling its capacity for fatty acids and derivatives by 1987.

One of the factors holding down prices—and profits—in the industry is simply that sales are slow. In addition, prices of fatty acids are being held down by the abundance of raw materials currently facing the industry. Tallow, one of the major raw materials, currently is priced in the

Diversity marks the fatty acid business



Source: R. M. Hull & Co.

Total 1981 consumption = 1.6 billion lb

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Fatty acid producers see big potential for synthetic lubes such as Mobil I

teens, down from more than 30 cents per lb, and coconut oil, another primary raw material, has slipped from a high of about 60 cents to less than 20 cents per lb. Customer pressure forces these price drops to be reflected in the price of fatty acids.

Fatty acid prices also are being affected by the depressed prices for one of the major forms of fatty acids, tall oil fatty acids. Tall oil fatty acids are coproducts of tall oil resins, which have been in demand lately to replace petroleum resins for a variety of specialty applications, particularly in adhesives. As one industry observer explains it, the demand for resin esters is up, encouraging more production. This means more production of tall oil fatty acids, which producers must then get rid of—and a low price usually is the easiest way.

The price and profit situation leads consultants at R. M. Hull & Co., Greenwich, Conn., who follow fatty acids, to have a somewhat jaundiced view of the business. "Off the top, it looks pretty grim," says R. M. "Pete" Hull, president of the firm. The growth rate up to 1980 had been running at about 2.2% per year, he says; and is expected to increase slightly to about 2.9% per year through 1985. "It's dynamically slow, like molasses," he says.

However, even with all the problems facing the industry, some producers maintain that there are bright spots waiting for growth. And they defend the seeming unwisdom of plant expansions, authorized and begun in better economic times.

"Actually, these show good timing," insists one marketer. "We usually build when product is scarce, and then the bottom falls out of the market. This time, most of this new capacity will be coming on stream in 1983 and 1984, when things have turned around, and we will need it."

The major market that most fatty acid producers have their sights on is synthetic lubricants. It was the synthetic lubricant market that lured Celanese into the business in 1978 with its 40 million lb-per-year plant for producing heptanoic and pelargonic acids.

To date, however, this market has not developed the way many observers expected—or perhaps hoped—it would. "It's been a disappointment—it sure hasn't been the growth market we all thought," says one marketer. The major reason, one producer believes, is the lack of acceptance in the automotive market. He cites the reluctance of oil companies, with the obvious exception of Mobil Oil with its Mobil 1 lube, to put together synthetic formulations, or include the naturally derived fatty acids and derivatives in petroleum formulations. "We see the light at the end of the tunnel, but the tunnel keeps getting longer," he adds.

Instead of the mass automotive markets, synthetic lubricants have found specialty niches in such industrial applications as general chemical processing and in aircraft.

In addition to synthetic lubricants, fatty acid producers see potential in a variety of different markets. For example, some are working with formulators to develop cutting fluids to replace those based on mineral oil. The advantages offered are better performance and environmental behavior—resistance to oxidative degradation and fewer disposal problems because the synthetic fluids are water-based.

The humble candle also is coming in for some attention. Stearic acid long has been used in candles. At one point, 100% stearic candles were an alternative to beeswax; then stearic lost out to paraffin wax. Stearic still is used in small concentrations in most paraffin candles to promote more-even burning. Now, however, some candle makers are going back to 100% stearic acid candles because paraffin prices have gone up. Economics are the major driving force, but some argue that the resulting candles are a better product.

Other producers cite cosmetics as a promising area for improved growth for fatty acid esters in particular. "Cosmetics are not recession-proof, we have to concede that now," says one producer. "But they are recession resistant, and naturally derived fatty acids and derivatives will continue to grow in this area."

Fatty acid producers generally agree that the more specialized they can make their products—specialty derivatives, for example—the greater the chance for success. To some extent, that's difficult. "Fatty acid technology is old and grass-roots," says one marketer, "and with the business not growing very fast, it is difficult to make a high return on investment even with forward integration into derivatives."

Nonetheless, that's the course of action most producers are counting on—that, and the fact that their products have what they see as a plus in naturally derived, renewable raw materials.

One producer cites the proposed Conoco detergent-alcohol plant as an example. Conoco already has a 135 million lb-per-year alcohol plant, fed with petrochemicals. Prior to its merger with Du Pont, however, it had plans for a similar or slightly smaller plant to be fed with natural materials (C&EN, Jan. 11, page 13). "The only reason Conoco has that on the back burner is because of the Du Pont acquisition—they are short of cash," he says. "But they remain very strong on it. They can see the justification for it, as insurance so they can move in either direction."

"People have been looking at petrochemicals as building blocks," says a market development manager, "and now they will be looking more at tallow." At least, that's what fatty acid producers are hoping, as they add to now-abundant capacity while waiting for a pickup in demand in the coming years. □

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Canada sees lucrative styrene export market

Already significant exporter of monomer, Canada will nearly double capacity by 1985; best markets will be the U.S. and Far East

It is pretty difficult to find an optimist in today's styrene business. Difficult, but not impossible, especially if you look in Canada.

One such optimist is Harry V. Blair and it's not fair to say that he is optimistic only because his company isn't in the styrene business. It soon will be.

The Canadian government doesn't report styrene production, but it does give figures for polystyrene, the monomer's primary outlet. Through the first seven months of this year, Canadian polystyrene production has been running 6% ahead of last year's, but output of other major thermoplastics has been down anywhere from 3 to 15%.

More important, Blair, business center manager of aromatics for Shell Canada Chemical Co., Toronto, says that Canada will emerge from the 1980s as one of the very few major styrene exporting powers in the world.

The U.S., still a volume styrene exporter, will become, instead, a large styrene importer. Western Europe, Latin America, and the Far East will become even larger importers than they are now. These areas represent lucrative export targets for those countries that can produce styrene economically over and above their own domestic needs.

Canada will be one of those countries, Blair told a session on marketing Canadian petrochemicals at a meeting of the Canadian Society for Chemical Engineering in Vancouver, B.C.

Canadian styrene producers won't have the field to themselves. By the mid-1980s, Blair expects Mexico to bring its production and consumption into balance. And, by the late 1980s, Mexico could become a net styrene exporter. That, of course, depends on how rapidly Mexico restores its economy and puts its petrochemical plant-building program back on track.

Saudi Arabia also will be a major contender for future styrene export markets. Blair expects Middle East (including Africa) styrene capacity to be 315,000 metric tons, including a hefty 295,000 metric tons of Saudi capacity due on stream in 1985 or 1986.

Despite the potential competition from Mexico and the Middle East, Canada should be able to get a head start in the international marketplace. It already is a significant styrene exporter; it sent an estimated 100,000 metric tons out of the country last year.

Canada's present styrene capacity is 465,000 metric tons. Polysar has a 385,000-ton plant and Dow Chemical Canada has an 80,000-ton unit, both at Sarnia, Ont. But consumption is only slightly more than 200,000 metric tons (1981).

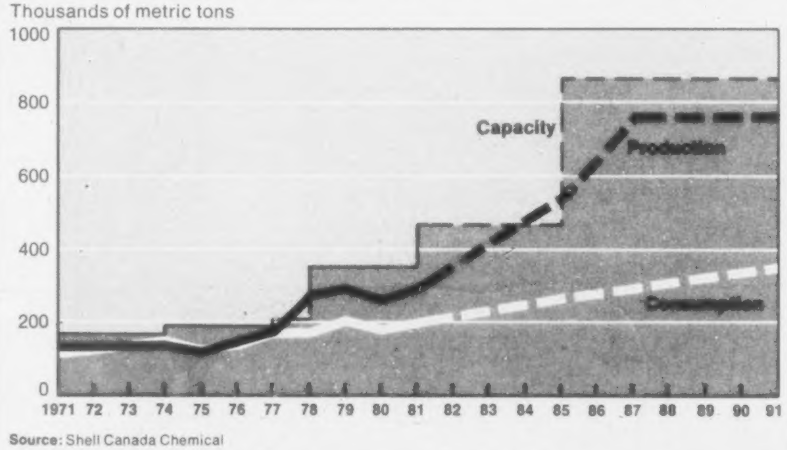
By 1985, before either Mexico or Saudi Arabia will be able to grab an international styrene toehold, Canada will almost double its styrene capacity. Shell Canada will have its 300,000 metric-ton unit on stream at Scotford, Alta., in 1984. And by 1985, Dow could have a 100,000 metric-ton expansion ready at Sarnia. There's some doubt about whether this expansion actually will be built, but so far the company hasn't said that it will be canceled. Blair figures that it will be part of Canada's styrene picture in 1985.

What he is not pumping into the supply side of his styrene equation, however, is a 400,000 metric-ton plant that had been proposed for Bruderheim, Alta. This unit was to have been a joint effort of Alberta Energy Co. Ltd. and Esso Chemical. Esso has pulled out of the project and AECL still is looking for a new partner. Although the project has received approval from the Alberta government, it is on hold and plans are indefinite.

Canada's styrene demand will not keep pace with this huge capacity increase. Blair estimates that demand, led by polystyrene, will increase an average 8.1% per year between 1981 and 1985. Then market growth will slow to a 4.5% annual rate through 1991. These rates indicate that Canadian styrene producers probably will be able to market 277,000 metric tons on their home turf in 1985 and 361,000 metric tons in 1991.

These rates also mean that, in 1985, Canadian styrene producers will be in a position to sell as much in the export market as they will in their domestic market. By 1991, exports will exceed domestic sales. Blair pegs the 1985 and 1991 export potential at 275,000 metric tons and 417,000 metric tons, respectively.

Canada will have plenty of styrene available for export



Source: Shell Canada Chemical

The big question, of course, is where will all of this Canadian styrene go? Blair thinks it can find profitable markets in the U.S. and Far East. Some will go to Western Europe, although he concedes that Europe is a logical market for Middle East styrene when it becomes available.

The U.S. has been a perennial heavyweight in styrene exports, with export volume running between 400,000 and 500,000 metric tons since the mid-1970s. The U.S. will continue to be a major factor in world exports until 1985. Then its styrene exports will start dwindling. By 1988, Blair thinks that the U.S. will become a net styrene importer.

Indeed, by 1991, the U.S. likely will be importing about 460,000 metric tons of styrene. And the U.S. market will be gobbling up virtually all of Canada's styrene exports.

Until then, the Far East will remain a hefty outlet for Canadian styrene. Japan, which has been a small net exporter, will satisfy virtually all of its own domestic demand until the mid-1980s. Then it will require a small amount of imports.

Japan's high-priced feedstocks will prevent it from participating in the export market, even though it will have excess capacity.

The remainder of the Far East, including Australia, historically has been a styrene importing area. It has had adequate capacity, but it can't compete with lower-priced U.S. and Canadian material.

Between 1981 and 1985, 475,000 metric tons of new capacity is scheduled to come on stream in the Far East. These newer plants will make the region more competitive with most exporting countries, says Blair. The possible exceptions are Saudi Arabia and Canada. By 1991, he figures that the Far East will be importing 447,000 metric tons of styrene.

Meanwhile, Western Europe's dependence on styrene imports will grow phenomenally. Blair says its styrene imports will rise from last year's 107,000 metric tons to 858,000 metric tons in 1991.

Canadian styrene producers, then, should have an excellent opportunity to capitalize upon its export potential. Blair sees a worldwide shortage of styrene developing by 1988.

Between 1980 and 1991, he expects world demand to increase an average 4.6% per year, whereas capacity will trail at only 1.8% per year. That combination spells good business for a country that has competitive, surplus styrene capacity. ☐

Canadian ammonia faces some big hurdles

Alberta, linchpin of western Canada's ammonia industry, will play host next year to almost 900,000 metric tons of new ammonia capacity.

On the surface, the timing couldn't be worse. The world fertilizer industry is limping through one of its worst business slumps. Demand is down. Plants are being shuttered—some temporarily, others permanently. Sharply lower prices can't keep many producers at the break-even level.

Still, says R. E. Ward, if western Canada ammonia producers can struggle through the next few years, they should emerge around the mid-1980s in pretty good shape.

Ward, who is planning and business development manager, chemical and fertilizer marketing, for Cominco Ltd., also has another big "if." He told a recent meeting of the Canadian Society for Chemical Engineering in Vancouver, B.C., that much depends on the natural gas situation in Alberta.

More than 90% of western Canada's ammonia capacity has been built in Alberta because of the province's huge, economical supply of natural gas. Feedstock represents about 80% of ammonia production costs. Whether or not Alberta producers will be able to compete effectively with U.S.-produced material and overseas production competing with Canada for a share of the U.S. market depends on Alberta natural gas prices.

Past forecasts of higher world oil prices and higher U.S. natural gas prices indicated that Alberta's natural gas price would give ammonia producers there a sizable feedstock advantage. They need it to offset higher transportation costs.

This advantage has narrowed as world energy prices have softened and as Canadian energy policies have made natural gas more expensive in Alberta.

Still, Ward thinks that prospects for Alberta's ammonia producers are bright. Demand in their own backyard, the grain-producing provinces of western Canada, is strong.

Ward expects nitrogen fertilizer demand in western Canada to increase 6.5% per year through the 1980s. Factoring in nonagricultural uses, western Canada's requirements will jump from 753,000 metric tons last year to 1.5 million metric tons in 1991.

By comparison, nitrogen demand in the U.S. probably will grow only 1.5 to 2% annually. However, even this growth is important to Alberta's producers because the U.S. is the only other major market for their ammonia. Canada has no port facilities to handle liquid ammonia; it must be sold on the continent.

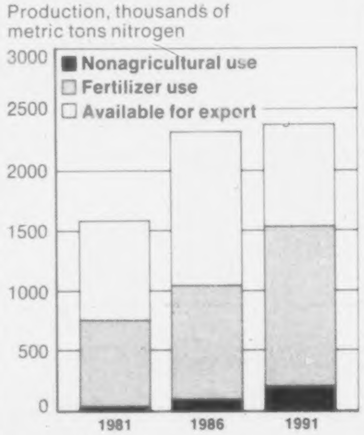
Last year, western Canadian ammonia producers had about 815,000 metric tons (as nitrogen) available for export. Export potential, however, will increase as new plants come on stream in Alberta next year. Esso Chemical Canada is bringing on a 540,000-metric-ton plant at Redwater, Alta., and Sherritt Gordon Mines Ltd. also will finish its 340,000-metric-ton ammonia plant at Fort Saskatchewan early next year. Both projects have accompanying urea plants.

These units, along with a modest expansion at Simplot Chemical's Brandon (Manitoba) plant, will raise western Canada's capacity to 1.9 million metric tons. Ward says the new capacity will raise producers' ability to export from last year's 815,000 metric tons to almost 1.3 million metric tons by 1986.

However, if no additional ammonia plants are built in western Canada, Ward points out that growing domestic demand will take a big slug of the material available for export markets. Without new plants, he says that export potential by 1991 will be right back to where it was last year.

But Ward also suspects that new plants will be built. He's expecting at least two new ammonia units in Canada—one in Alberta and one in British Columbia. ☐

Nitrogen fertilizer export potential will decline



Source: Cominco Ltd.

1983 Employment Outlook

Career Opportunities for Chemical Professionals

This year is discouraging for many chemists and chemical engineers seeking employment. Because of the general economic slowdown, employers clearly have reduced their recent hiring of chemical professionals.

This is borne out by a decrease in the number of job offers received by inexperienced graduates. According to an ACS study, the average new B.S. chemist received 1.17 job offers in 1982, down from 1.44 offers in 1981, and the average new Ph.D. chemist got 2.12 offers in 1982 (2.24 in 1981). For chemical engineers, the decline is more marked. The average new B.S. chemical engineer received 2.20 offers in 1982, compared to 3.68 in 1981. The average new Ph.D. chemical engineer got 3.24 offers in 1982, down from 5.53 the previous year.

Universities report that, although the employment situation for their graduating chemists and chemical engineers was good in the fall of 1981, a sharp downturn occurred about the first of 1982.

Many campus observers believe the hiring outlook for the 1982–83 academic year is highly uncertain. They are hoping that an improvement in the economy will push up the demand for chemical professionals, although some observers are far from optimistic.

An ACS study finds that, between 1981 and 1982, the median annual starting salaries of inexperienced chemists decreased 1% for B.S. graduates and increased 12% for M.S.s and 10% for Ph.D.s. Among inexperienced chemical engineers, starting salaries rose 9% for B.S.s, 11% for M.S.s, and 11% for Ph.D.s.

These are some of the findings of C&EN's latest report on the employment situation for chemical professionals, prepared by senior editor Howard J. Sanders.

Chemical Engineers

Chemical engineers typically draw higher salaries than chemists, despite equal amounts of training and job experience. Engineers usually require less academic training than chemists because they are less apt to do independent research. **Page 38**

Demand

Demand for chemists and chemical engineers this year is decidedly less than in previous years, as a result of the deep business recession. New college graduates are receiving fewer job offers, and some still are looking for suitable employment. **Page 43**

Salaries

The median annual salaries of experienced and inexperienced chemists and chemical engineers rose moderately this year, except for a slight decrease for inexperienced B.S. chemists. Inflation, however, appreciably eroded the gains. **Page 49**

Career Planning

Much information for people considering careers in chemistry or chemical engineering is available from ACS and other organizations. A directory provides names and addresses of many employers of chemical professionals. **Page 52**

Chemical Engineers

Linked by chemistry, chemists and chemical engineers differ in many ways, including schooling and pay

Chemists and chemical engineers share a mutual bond in chemistry. But the two professions are quite different.

Chemists are most likely to work in research laboratories; chemical engineers in manufacturing plants. The work of most chemists requires a Ph.D.; chemical engineers generally find B.S. training sufficient. Chemists usually work with small amounts of materials, using scientific instruments; chemical engineers deal with large volumes and production-scale equipment. The job of the research chemist is to uncover new knowledge; the typical chemical engineer solves practical problems using existing knowledge. Not the least of the differences between the two: chemical engineers tend to be better paid. Why do chemical engineers generally earn more money than chemists, even if both have the same number of years of university training and professional experience?

The salary difference is large. A survey by the American Chemical Society shows that the median annual starting salary of inexperienced B.S. graduates this year is $26,500 for chemical engineers—56% higher than that for B.S. chemists.

An earlier ACS study, covering members at all professional experience levels, shows that, as of March 1982, the median annual salary of B.S. chemists was $28,500 and that of B.S. chemical engineers was $40,000—40% more. The latter figure is somewhat distorted, however, because ACS-member chemical engineers are a somewhat older and thus more experienced group than chemical engineers in general, as shown by data from the American Institute of Chemical Engineers, whose members are more representative of the total chemical engineering profession. Thus, in March 1982, the median annual salary of AIChE members (encompassing all degree levels) was about $39,000, whereas the median annual salary of ACS-member chemical engineers was $42,000.

The most common explanation for the higher salaries paid to chemical engineers can be summed up by the terse statement: "Supply and demand." For employers to compete in the hiring marketplace, they have to pay more for the scarcer "commodity"—chemical engineers.

Since, for some years now, chemical engineers have been in relatively short supply and have been paid comparatively high salaries, why don't more young people choose careers in chemical engineering? One explanation is that many young people are not aware of the salaries paid to chemical engineers or of the demand for them. In fact, some young people seem to be aware only vaguely that the chemical engineering profession exists.

Many high school students take courses in chemistry and so are moderately familiar with the work that chemists do. And many young people also have chemistry sets and, through them, have developed a liking for the subject. No courses in chemical engineering are offered in high schools, and no kits are on the market to show young people what the field is like. And whereas at least a few movies, television programs, and best-selling books have described what chemists do, the same cannot be said for chemical engineers.

Another factor discouraging young people from obtaining degrees in chemical engineering is that the chemical engineering curriculum is regarded widely as one of the toughest on many campuses. Says one chemical engineering professor, "When I was going to college and mentioned that I was majoring in chemical engineering, the usual response was an offer of condolence." Its reputation for being especially difficult steers many students away from engineering.

Course work leading to a B.S. in chemical engineering generally is more strenuous than that leading to a B.S. in chemistry. The chemical engineer is required to take a greater number of technical courses than is the chemist. As a whole, the courses for chemical engineers often are more challenging intellectually, involve more mathematics, and require longer hours of homework. Chemical engineering professors also are prone to set high grading standards. In addition, the chemical engineering curriculum includes fewer nontechnical electives than that of the chemist, which may be less demanding than the technical electives of chemical engineers.

Freshman enrollments in chemical engineering in recent years have been increasing rather dramatically, nevertheless. This is reflected in the number of B.S. degrees awarded in the past few years, which has climbed from 3581 in academic year 1976–77 to 6527 in 1980–81. The increase is attributable largely to a growing student awareness that chemical engineers are in high demand and are relatively well paid. Admittedly, the demand for these graduates decreased this year because of the nation's severe recession. But this decline is expected to be only temporary.

C&EN staff photo

Cheh: Surplus of chemical engineers is not expected in the foreseeable future

The sharp rise in the output of new B.S. chemical engineers in the past few years has led some observers to wonder whether a surplus will develop, resulting in a leveling off, if not a decline, in starting salaries. Most observers, however, do not believe that a significant oversupply will occur.

One reason is that the rise in the supply of chemical engineers has been accompanied by an increase in demand not only by the chemical industry but also in such fast-expanding fields as the development of new energy sources and the creation of better ways to protect the environment.

Huk Y. Cheh, chairman of Columbia University's department of engineering and applied chemistry, declares, "I do not expect a surplus of chemical engineers to develop in the foreseeable future because the industries that employ them are vital to the nation's economy. On the other hand, a chemical engineering senior nowadays may get only one or two job offers, whereas he or she in former years might have gotten three or four."

C&EN staff photo

Han: Companies can put chemical engineers' training to effective use

Many chemical engineering departments are putting a firm lid on their enrollment of freshman students. The reasons are mainly the shortages of chemical engineering faculty members, lecture room space, and laboratory facilities. In view of the scarcity of funds in the present tight economy, chemical engineering departments are not likely to add new wings onto their present buildings to accommodate an overabundance of students.

One observer notes, "Especially hard hit have been the state universities. They have been faced with cutbacks in funding not only because of the recession but because of the public's widespread tax revolt and the stiff competition for state funds by other public programs. Hence, many state universities simply cannot handle a sharp rise in enrollments."

The University of Maryland's college of engineering last year set up an enrollment limitation plan. In academic year 1981–82, freshman enrollments in the various engineering departments were reduced one third from the previous academic year.

This type of curtailment also is being imposed in many other engineering schools. The restrictions help the schools provide quality education for their students and enable them to stay within their limited budgets. In August, the engineering deans council of the American Society for Engineering Education unanimously passed a resolution recommending that engineering schools limit or even decrease their enrollments to prevent faculty shortages and crowded classrooms from impairing engineering education.

The shortage of chemical engineers is only one factor behind the higher salaries that they earn. Chang Dae Han, head of the chemical engineering department at Polytechnic Institute of New York, says, "I believe that another reason is that the professional work of B.S. chemical engineers is less routine and more demanding than that of the usual B.S. chemist. Also, chemical engineers are more broadly trained in areas that companies can put to effective use. Compared to a B.S. chemist, a B.S. chemical engineer knows much more about such commercially useful matters as heat transfer, fluid flow, mass transfer, chemical reaction kinetics, process automation, equipment design, and process economics."

Others believe that employers attach a higher value to chemical engineers because they are viewed as more production-minded, more cost-conscious, and more management-minded than are chemists. Hence, they are in a better position to move eventually into high-level executive jobs.

Dale B. Fox, manager of university relations and professional employment at Monsanto, says, "Offhand, I can think of several B.S. chemical engineers in our company who are plant managers. On the other hand, I can think of no plant managers in our company who are B.S. chemists."

Some people, such as James M. Bobbitt, chemistry professor at the University of Connecticut, believe that chemical engineers are more highly paid than chemists because their work brings their employers a more immediate payoff. Clearly, the activities of a chemical engineer are more closely tied to the finished, marketable product than are those of the research chemist.

Alexis T. Bell, chairman of the chemical engineering department at the University of California, Berkeley, comments, "Industry places a higher premium on chemical engineers than on chemists because chemical engineers can deal with a broader range of problems that have a direct bearing on a company's profitability. For example, a chemical engineer, unlike a chemist, is concerned about the cost of raw materials

Fox: Some B.S. chemical engineers are promoted to plant managers and can develop the most economical route to a given chemical end-product."

Other observers say that chemical engineers are more valuable to employers because they are more versatile than chemists. This greater versatility, says John H. Seinfeld, executive officer for chemical engineering at California Institute of Technology, stems from the fact that chemical engineers must carry a heavy course load in both chemistry and chemical engineering. "As a result," he notes, "they can function as both chemists and engineers. Thus, they can work effectively in many different types of jobs."

Chemical engineers are said to have certain highly desirable personality traits, such as the ability to make quick decisions and to function well with many different types of people—traits found less often among chemists.

Another reason sometimes given for the higher salaries paid to chemical engineers is that their jobs often place them in positions of higher responsibility—both in terms of people and money. Chemists often work alone or supervise only a small group of people in a laboratory; a chemical engineer may supervise dozens of people in a chemical plant. And whereas a chemist may be responsible for $20,000 worth of research equipment, a chemical engineer may be in charge of operating a $20 million plant.

Fox of Monsanto observes, "Compared to B.S. chemists, B.S. chemical engineers have to do a lot more immediate and independent decision making. And often this decision making, which customarily relates to plant operations rather than to laboratory operations, involves substantial sums of money."

An intriguing question is whether chemical engineers actually have personalities that differ from those of chemists.

Many people think that personality differences between the two groups are quite minor. Columbia's Cheh thinks "it is absurd to generalize about differences in the personalities of chemists and chemical engineers. Obviously, there is enormous diversity in both groups."

Nevertheless, some people do see differences. The chairman of the chemistry department at a major university says, "I have been studying the personalities of chemists and chemical engineers for more than 30 years now, and I definitely see differences. The chemical engineers as a group appear to be more emotionally and physically mature than the chemists—at least at the undergraduate level. They tend to be more aggressive. They are more confident about their vocational goals. They generally are less patient and thus more likely to expect quick results."

Seinfeld: Versatility stems from knowing both chemistry and engineering

Some observers say that chemical engineers tend to be more gregarious than chemists and more at ease in dealing with people at many different levels—everyone from maintenance workers and plant operators to scientists and company managers. On the other hand, chemists, they believe, tend to be more comfortable when dealing with their social and intellectual peers.

According to some people, chemical engineers have greater ability to make quick, well-reasoned decisions about relatively difficult problems. Hence, they tend to make better managers. They also are more people oriented and more cost conscious.

Some people claim, too, that chemical engineers are less interested in the humanities than are chemists. Joseph N. Cannon, chairman of the chemical engineering department of Howard University, says, "Our chemical engineering students take a few courses in the humanities, but quite a few of them loudly grumble about it—more so than do the chemists." In addition, he and some other observers believe that chemical engineers tend to be less verbal and to have poorer communication skills than do chemists.

Theodore W. Cadman, chairman of the chemical and nuclear engineering department of the University of Maryland, finds that chemical engineers tend to be less concerned than chemists about seeking political solutions to society's problems, preferring technological solutions instead. "In the Vietnam war years and later," he says, "relatively few of our chemical engineering students participated in campus protest demonstrations and other political efforts, whereas sizable numbers of the chemistry students were involved quite actively. One possible reason, of course, is that our engineers may have been too busy with their studies and may have been too preoccupied with preparing for their future professional careers to get involved in such extracurricular activities. I believe, however, that a more important reason is that chemical engineers generally are less interested than are chemists in getting involved in politics."

A notable trend in recent years has been the substantial increase in the number of chemical engineering graduates who are women. Some chemical engineering departments report that 20 to 25% of their B.S. graduating classes in the past two or three years have been women. In contrast, the University of Illinois at Urbana, for example, graduated very few women chemical engineers prior to about 1974.

Fifteen years ago, a woman chemical engineer—particularly one working in an industrial plant—was regarded as an oddity. Many chemical companies refused to allow women chemical engineers to do plant work because it was considered too strenuous or too dangerous. If a company hired a woman chemical engineer at all, it usually assigned her to a laboratory or office job.

All that has changed. Fox says, "Seeing a woman chemical engineer in a plant these days is no big deal." He points out that he has seen women chemical engineers climb ladders and walk across scaffolding as agilely as any male engineer.

Now many chemical companies are making a special effort to hire women chemical engineers. In 1981, median starting salaries of B.S. chemical engineers were $24,650 for women and a slightly lower $24,500 for men. In 1982, however, the median starting salaries of B.S. chemical engineers were $26,750 for women and a slightly higher $27,000 for men.

J. Charles Forman, executive director of AIChE, says, "Women are becoming increasingly interested in working as chemical engineers partly because they know that companies are eager to place them in interesting, challenging, and well-paying jobs. They also know that their male coworkers will accept them. Seeing women chemical engineers working in a chemical plant with their clipboards, data sheets, hard hats, and electronic calculators has become commonplace."

Fox declares, "Companies are eager to place qualified women chemical engineers not only in conventional chemical engineering jobs but in higher-level positions as well. I'll bet that, in the near future, you will find women chemical engineers employed as plant managers and in even higher positions, even if a few workers initially may find this change a bit difficult to accept."

Companies also are attempting to hire more engineers from minority groups. Many observers believe that qualified, young, black chemical engineers stand a very good chance of obtaining satisfying jobs in industry. On the other hand, some blacks say that, once hired, they have found it harder to advance than do their white counterparts. This situation, however, appears to be improving, as more black chemical engineers are moving into management positions.

Clearly, blacks are underrepresented in the chemical engineering profession. Only 0.7% of the members of the American Institute of Chemical Engineers are black, despite the fact that 11% of the U.S. population is black. Part of the reason is that blacks in the past have felt that the field essentially was closed to them.

Cannon of Howard University says that another factor holding back the entry of blacks into the chemical engineering profession is their often inadequate high school preparation in chemistry, physics, and math. He adds, "The job opportunities for black chemical engineers are excellent. We almost always have decidedly more job offers for our chemical engineering graduates than we have applicants. In the many counseling sessions I have had with black high school students over the years, I have strongly encouraged them to go into chemical engineering—provided they have a liking for and an aptitude for chemistry, physics, and mathematics."

C&EN staff photo

Cannon: Job opportunities for black chemical engineers are excellent

Even though chemical engineering and chemistry are looked upon as two separate professions, no rigid line of demarcation actually exists between the two. Both fields rely heavily on chemistry.

As their experience grows, some chemical engineers do work that normally would be done by chemists. Conversely, chemists who pick up on-the-job experience or take courses in engineering may move into jobs typically done by chemical engineers.

In the pilot plants of many companies, chemists work alongside chemical engineers, often doing similar work. Sometimes it is difficult to tell one from the other. Eugene O. Gooding, a chemical engineer who is business manager for chlorine and caustic soda at Dow Chemical, says, "There is definitely a gray area between chemistry and chemical engineering, and the pilot plant is often a meeting ground for these two professions."

Van T. Boughton, vice president of W. R. Grace's industrial chemicals group, comments, "After people spend 10 or more years in industry, the significance of the title on their college degree tends to diminish. This is especially true when chemists and chemical engineers move into such fields as marketing or management."

For high school seniors and college freshmen who have a strong interest in both chemistry and chemical engineering, many career advisers recommend work toward a B.S. in chemical engineering. The reason is that such students, if they later decide they would rather have a B.S. in chemistry, already will have taken most of the required chemistry courses.

On the other hand, students who obtain a B.S. in chemistry and then decide they prefer chemical engineering find switching will be more difficult and time consuming because they will have to take many required engineering courses.

C&EN staff photo

Cadman: Search goes on for technological answers to society's problems

Some advisers urge that students majoring in chemistry who are debating whether they prefer chemical engineering, should get a summer job or a co-op job in industry to get some exposure to day-to-day chemical engineering work. Another suggestion is to take some of their technical electives in engineering.

Actually, some vocational guidance counselors and industry personnel administrators urge chemistry majors to take elective courses in chemical engineering, even if they definitely have decided on a B.S. in chemistry. Knowledge of chemical engineering is highly useful to chemists and improves their chances of finding industrial employment.

Not everyone agrees, however. Thomas M. Dunn, head of the University of Michigan's chemistry department, declares, "We have strongly resisted the efforts of companies to get us to inject chemical engineering courses into our chemical curriculum. We believe that our B.S. chemistry graduates should be primarily chemists and not a hybrid of a chemist and a chemical engineer. We train our B.S. chemists to be generalists."

Most chemical engineers have only a B.S. degree. On the other hand, the majority of chemists who work in research laboratories have Ph.D. degrees. Why do chemical engineers generally need less academic training?

A major reason is that a Ph.D. in chemistry or chemical engineering is

C&EN staff photo

Forman: More and more women chemical engineers are working in industry

needed mainly by people in these fields who do laboratory research. Since chemists typically do such research, they need a Ph.D. On the other hand, since most chemical engineers do not do laboratory research, they do not require a Ph.D. Obtaining such a degree would constitute overtraining.

Polytechnic Institute's Han comments, "Most chemical engineers get only a B.S. degree because employers find that B.S. training is sufficient for the type of work they customarily are expected to perform. Any additional training they may need usually can be gotten on the job."

Another explanation is that typical chemical engineers apply scientific knowledge developed by others. They are not called upon to invent a novel reactor or new distillation column but merely to design one, using information previously obtained by others or select a unit that already is available commercially.

Many chemical engineers, too, are involved in supervising plant operations or trouble-shooting. This work also does not require the breadth of scientific knowledge or creative ability demanded of research chemists and chemical engineers.

Few chemical engineering students, in fact, get Ph.D. degrees. In the academic year 1980-81, only 300 Ph.D. degrees were earned by chemical engineers in the U.S., compared to 6527 who received B.S. degrees in chemical engineering. Whereas the number of students obtaining B.S.s in chemical engineering has been increasing in recent years, the number getting Ph.D.s in this field has declined from a peak of 400 in 1973-74.

One reason for the decline is that the starting salaries are now so high that many chemical engineering students are strongly tempted to end their formal academic training at the B.S. level.

Moreover, students realize that in going for a Ph.D. they will lose the three or four years of relatively high income that they would receive if they took a job in industry.

Despite this initial loss, however, the total earnings of a Ph.D. chemical engineer over the course of a career almost always are greater than those of a B.S. chemical engineer.

Recruiters in both industry and academia point out that a great need exists now for more Ph.D. chemical engineers. Many industry people have indicated a keen interest in hiring more Ph.D. chemical engineers to do engineering research. Many of these engineers eventually will go on to positions in management.

University chemical engineering departments are in a particular bind at present. They have to cope with increasing enrollments in their undergraduate courses but are short of Ph.D. faculty members to teach them. According to Cheh of Columbia University, the typical U.S. chemical engineering department today has openings for about two faculty members—and is not particularly encouraged about the prospects of filling these positions.

Most Ph.D. chemical engineers take jobs in industry, where the salaries are higher than in academia. A problem for the universities is that a growing number of Ph.D. graduates are foreign born. Many have come to the U.S. from such countries as Taiwan, Korea, India, Iran, Iraq, and the Philippines.

Unfortunately, some are not sufficiently fluent in English to qualify as chemical engineering teachers in this country. And, although most of them would like to remain in the U.S., many cannot because the regulations of the Immigration & Naturalization Service force them to leave when their student visas expire.

A B.S. chemical engineer who wishes to get advanced academic training in chemical engineering but does not want to get a Ph.D. might well be advised to obtain an M.S. in the field. Getting this degree usually takes a year to a year and a half. The course work consists mainly of basic studies in chemical engineering and its applications, and may involve independent research leading to the writing of a thesis.

As can be observed occasionally on college campuses and in industry, a certain amount of joshing goes on between chemists and chemical engineers. Chemists may refer to chemical engineers as "nothing more than plumbers." Chemical engineers may speak of chemists as "just a bunch of test-tube pushers."

Some chemists, particularly research chemists, think of their work as more useful to society than that of chemical engineers. Research chemists tend to regard themselves as highly inventive. They discover useful compounds where no such compounds previously existed. Some chemical engineers, on the other hand, tend to think of their work as more socially worthwhile. Without their efforts, new compounds would remain forever as nothing more than curiosities sitting on a laboratory shelf.

Despite such mutual bantering, the work of chemists and chemical engineers is, in reality, interdependent. Without the chemists, chemical engineers would have no need to design and operate new plants to make new compounds. Without the chemical engineers, the work of the chemists never would be commercialized, and potential users never would have access to them.

Dunn of the University of Michigan comments, "A healthy rivalry has long existed between chemists and chemical engineers. Each group, of course, has a certain ego. But the two groups generally work well together, despite their competitiveness and good-natured kidding. Indeed, I would describe the relationship of the two groups as a clear case of symbiosis." □

Boughton: Significance of exact title on one's college degree diminishes

Weak economy tightens the screws on this year's job market for chemists and chemical engineers

Demand

In a year of severe recession, it is not surprising that the demand for chemists and chemical engineers is noticeably less than in 1981. This decline has been evident from a variety of indicators.

For example, the volume of classified advertising in C&EN for new employees so far this year is decidedly less than in the comparable period of 1981. And recruiting activity at ACS's National Employment Clearing House in Kansas City last month was unusually slow.

Last year, some universities reported that recruiting activity for graduating chemists was good, whereas at other schools it was considerably less than the previous year. This year, on the other hand, almost all schools contacted indicate that job opportunities for their graduating chemists are disappointing. Some schools said that a few 1982 graduates still have not found employment.

Rebecca J. Simon, placement director for the University of Illinois' school of chemical sciences at Urbana, reports that the number of job offers made to graduating chemists and chemical engineers at all degree levels in academic year 1981–82 was about half of what it had been in recent years. A few employers withdrew interview invitations they had made to graduating students, and, in two or three cases, employers actually retracted job offers to students.

Simon also points out that employers originally scheduled an unusually large number of recruiting visits in 1981–82 (270 visits, compared to 253 in the previous academic year). However, employers later canceled many visits (48 in 1981–82, compared to 26 in the previous year). As a result, the number of visits actually made was 222 in 1981–82, compared to 227 in 1980–81. Most of the visits canceled at Urbana in 1981–82 were during the spring recruiting season. "Many companies," Simon comments, "felt they had seen enough students to fill their needs as a result of interviews conducted in the fall."

Simon also says that a larger number of employers than usual have canceled their fall recruiting visits this year. Some companies that normally recruit more than once during the school year, she notes, are making fewer visits. Most recruiters have fewer jobs to fill than in past years. However, if the economy picks up in the coming months, recruiting in spring 1983, she believes, may improve noticeably.

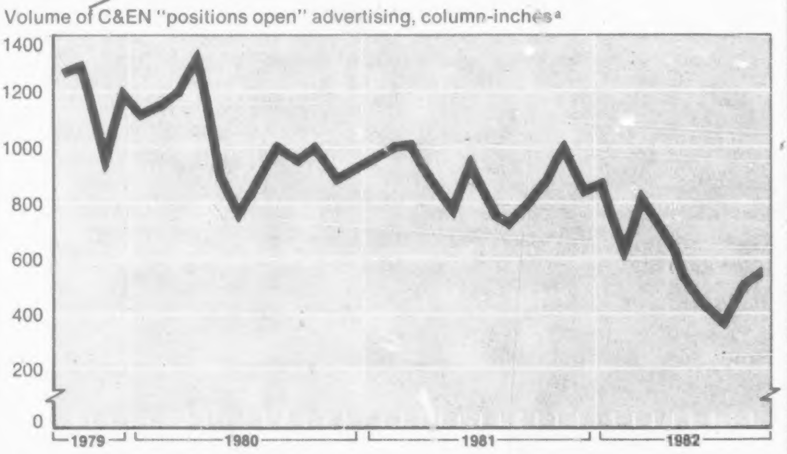
At the University of Wisconsin, the number of employers who recruited graduating chemists on the campus decreased slightly from 78 in 1980–81 to 76 in 1981–82. Recruiters mainly were from companies in the chemical, petroleum, and pharmaceutical industries.

Audrey L. Aylesworth, chemistry placement coordinator at Wisconsin, finds that many employers visiting in 1981–82 were uncertain about the number of chemists they wanted to hire. Some recruiters clearly have no specific openings in mind but merely are interviewing students on the possibility that an unexpected opening might occur.

At the University of Wisconsin, B.S. chemistry graduates received an average of 1.0 job offer in 1981–82, compared to 1.2 offers in the previous academic year. On the other hand, the demand for Ph.D. chemistry graduates improved to an average of 3.1 job offers in 1981–82, compared to 2.6 in 1980–81.

Aylesworth expects about the same number of employers to interview the

Recruitment advertising drops sharply in 1982



[a] Total volume of "positions open" advertising in four consecutive issues of C&EN. No issues were published in the last week of December 1979, 1980, and 1981.

Hiring of chemical professionals is declining, C&EN survey indicates

Employers are hiring markedly fewer chemists and chemical engineers in 1982 than they did in 1981. They expect to hire even fewer in 1983. In brief, the employment outlook for chemical professionals this year and next, according to a recent C&EN survey, is far from encouraging.

Most employers responding to the survey believe, however, that the employment outlook for chemists and chemical engineers over the next five years is good to excellent. Nevertheless, they are not so optimistic this year as they were a year ago.

This year, 8% of the respondents say the employment outlook for chemists in their organizations is excellent, 23% think it is very good, and 50% call it good. On the other hand, last year the corresponding results were 3% excellent, 58% very good, 33% good.

As for chemical engineers, 4% of the responding organizations this year say that the employment outlook in their organizations over the next five years is excellent, 46% call it very good, and 29% consider it good. In contrast, last year's results were 34% excellent, 21% very good, and 31% good.

The C&EN survey of the hiring activity and plans of leading U.S. employers of chemists and chemical engineers covered 27 organizations, including some of the nation's largest chemical companies as well as a few research institutes. Most are in the chemical industry, although some are in such related fields as petroleum, rubber, metals, and pharmaceuticals. They currently employ about 13,000 chemists and 16,000 chemical engineers.

Between mid-1981 and mid-1982, the number of chemists on the staffs of these organizations declined 1%, but the number of their chemical engineers increased 3%. Between mid-1982 and mid-1983, they expect the numbers of their chemists and chemical engineers to decrease 1%.

Respondents say they are hiring 39% fewer chemists this year than in 1981. And they plan to hire 11% fewer chemists in 1983 than in 1982. They also are hiring 36% fewer chemical engineers in 1982 than last year and expect to hire 33% fewer in 1983 than in 1982.

Most of this hiring will be from recent college graduates. For chemists, the proportion of new employees who were new graduates was 69% in 1981 and 74% in 1982 and is expected to be 77% in 1983. For chemical engineers, the figures were 80% in 1981 and 86% in 1982 and is expected to be 82% in 1983.

The current recession has caused a marked reduction in the number of college recruiting visits by employers looking for chemists and chemical engineers. In their search for chemists, employers made 9% fewer visits to college campuses in academic year 1981–82 than in 1980–81. They expect to make 28% fewer visits in 1982–83 than in 1981–82. To recruit chemical engineers, they made 9% fewer campus visits in 1981–82 than in the previous year. They plan to make 34% fewer such visits in 1982–83 than in the previous year.

The C&EN survey asked employers how the recession has affected their hiring of chemists in the past 12 months. For 46%, it has affected their hiring of chemists greatly. For 42%, it has had a moderate effect, but for 12% little or none.

Asked for general comments on the effects of the current business decline on their hiring of chemists, organizations gave such replies as: "Our reduced hiring of chemists reflects the general slowdown in the economy." "At present, we are not hiring any new personnel." "The current poor economic climate will significantly affect job opportunities for chemists because of major reductions in our R&D programs and our lower production levels." "Hiring here has come to a virtual standstill." "Until business conditions improve substantially, we will hire only replacements for employees who retire or resign."

Employers also were asked when they thought job prospects for chemists would get better because of an improvement in business conditions. Fully 40% of the respondents said that job prospects would improve in the second quarter of 1983, 27% said the third quarter, and 20% said the fourth quarter, but 13% see no improvement before 1984.

As was true last year, the three types of chemical specialists in greatest demand by employers this year are analytical chemists, organic chemists, and polymer chemists. Employers also expressed a special interest in biochemists, physical chemists, inorganic chemists, nuclear chemists, and organometallic chemists.

The C&EN survey also indicates that the percentage of chemists who are women seems to have leveled off. It was 12% in 1981 and 1982 and is expected to remain 12% in 1983. On the other hand, the percentage of chemical engineers who are women is expected to increase slightly next year. It was 7% in 1981 and 1982 and is predicted to rise to 8% in 1983.

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school's graduating chemists in 1982–83 as did so in the previous year. But she is uncertain about how many job openings these employers will have. "On that question," she says, "we are holding our breath, particularly since we have heard that some employers have laid off some of their young chemists in recent months."

At Ohio State University, the slowdown in demand for graduating chemists began about January of this year. "The optimism we felt in September 1981," says Jean E. Eisel, director of career services for Ohio State's Colleges of Arts and Sciences, "was replaced by pessimism at about the start of 1982. A few of our well-qualified Ph.D. chemistry graduates are still looking for jobs in their fields."

Because of the difficult job situation, she notes, students have become decidedly less selective. Many companies indicate that more often than usual graduating chemists accepted job offers almost immediately. Eisel adds, "I think the employment situation for graduating chemists and other professionals will be even worse in 1982–83 than in 1981–82."

Demand for chemical engineering graduates at the University of Maryland was high in the fall of 1981 but declined sharply in early 1982, according to Theodore W. Cadman, chairman of the department of chemical and nuclear engineering. Companies apparently met their quotas for new chemical engineers in the final months of 1981 and then called off most of their recruiting interviews scheduled for early 1982. In some cases, definite offers to students were canceled abruptly, particularly if the student was slow to accept the offer.

Despite all the pessimism about the job market for chemical professionals, a survey by the American Chemical Society of its chemist members shows that only 1.5% were unemployed but seeking employment last March. This was only slightly higher than the unemployment rate of 1.1% in March 1981 and 0.9% in March 1980 (the lowest level since ACS began con-

Bachelor's degrees decline for chemists but reach new high for chemical engineers

Academic year	Degrees awarded in chemistry[a]			Degrees awarded in chemical engineering		
	Bachelors	Masters	Ph.D.s	Bachelors	Masters	Ph.D.s
1970–71	11,183	2284	2160	3615	1100	406
1971–72	10,721	2259	1971	3663	1154	394
1972–73	10,226	2230	1882	3636	1051	397
1973–74	10,525	2138	1828	3454	1045	400
1974–75	10,649	2006	1824	3142	990	346
1975–76	11,107	1796	1623	3203	1031	308
1976–77	11,322	1775	1571	3581	1086	291
1977–78	11,474	1892	1525	4615	1237	259
1978–79	11,643	1765	1518	5655	1149	304
1979–80	11,446	1733	1551	6383	1271	284
1980–81	11,347	1654	1622	6527	1267	300

a Does not include biochemistry and geochemistry. **Source:** Department of Education's National Center for Education Statistics

ducting employment surveys in 1971). The highest level of unemployment among ACS-member chemists was 3.2% in March 1972.

Unemployment among chemists remains markedly less than in the total U.S. labor force. According to the Bureau of Labor Statistics, that figure was 9.0% in March 1982 and climbed to 9.8% in August and to 10.1% in September. The unemployment rate for professional and technical employees, although much lower than that for the total U.S. labor force, also is on the upswing. It has risen from 2.7% in March 1981 to 3.2% in September of this year.

The highest unemployment rate for ACS-member chemists in March 1982 was among those with B.S. degrees, 2.2% of whom were unemployed but seeking employment, compared to 1.4% of those with M.S. degrees and 1.3% of those with Ph.D.s.

Typically, women chemists have a higher rate of joblessness than their male counterparts. In March 1982, 2.8% of ACS-member women chemists were unemployed but seeking employment, contrasted with 1.3% of male members. In March 1981, the comparable figures were 2.4% for women and 0.9% for men.

Final data on the unemployment rate among members of the American Institute of Chemical Engineers in early 1982 are not expected to be available until November. The preliminary estimate, however, is that, as of March 1982, 0.9% of AIChE members were out of work. This figure compares with 0.5% in early 1981 and 0.4% in early 1978, 1979, and 1980.

The falloff in the demand for chemical professionals is reflected clearly in the decreased volume of "positions open" advertising in C&EN. In its first 40 issues of 1982, C&EN published 6290 column-inches of such advertising—down 30% from 8962 column-inches in the first 40 issues of 1981 and down 41% from the 10,663 column-inches in the first 40 issues of 1980.

Another indication of lower demand for chemists and chemical engineers is activity at the National Employment Clearing House at ACS's fall 1982 national meeting in Kansas City, Mo., compared to the society's fall 1981 national meeting in New York City and the fall 1980 meeting in Las Vegas.

In Kansas City, only 112 employers used the clearinghouse, down from 300 in New York and 209 in Las Vegas. Job applicants totaled 468 in Kansas City, 697 in New York, and 356 in Las Vegas. But the number of positions listed for candidates' review dropped to 170 in Kansas City from 484 in New York and 375 in Las Vegas and the total number of job interviews was only 898 in Kansas City, compared to 2336 in New York and 1165 in Las Vegas.

Each job candidate averaged 1.9 interviews in Kansas City, fewer than the 3.4 in New York and 3.3 in Las Vegas. The average number of interviews at Kansas City not only was lower than for the fall ACS national meetings in the past several years but was also less than the 2.3 interviews per candidate at the fall meeting in Chicago in the recession year 1975.

According to Audra B. Rafter, manager of the ACS Employment Aids Office, the largest number of positions listed at the Kansas City clearinghouse was for analytical chemists (32 openings) and organic chemists (also 32). The runnersup were physical chemists (13 openings), biochemists (11), chemical engineers (11), and polymer chemists (nine). In contrast, at last year's national meeting in New York, there were 110 positions listed for analytical chemists, 74 for organic chemists, and 64 for polymer chemists. Of course, the New York area is a much larger center of chemical activity than is the Kansas City area.

Data from the College Placement Council in Bethlehem, Pa., based on reports from 161 colleges and universities, indicate that markedly fewer job offers were made to graduating students in the 12 months ending July 1982 than in the previous 12 months. Candidates for B.S. degrees in chemistry received 36% fewer offers, inexperienced candidates for M.S. degrees in chemistry received 52% fewer offers, and Ph.D. candidates in chemistry got 33% fewer offers.

The job situation was disappointing also for chemical engineers. B.S. chemical engineering students received 46% fewer job offers in 1981–82 than in 1980–81. Inexperienced M.S. candidates got 58% fewer offers, and Ph.D. candidates likewise got 58% fewer offers.

The availability of chemists is influenced greatly by the number who graduate each year. According to the Department of Education's National Center for Education Statistics, B.S. degrees awarded in chemistry declined from 11,446 in academic year 1979–80 to 11,347 in 1980–81. B.S. degrees in chemistry previously had increased every year from 1973–74 through 1978–79. On the other hand, the number of Ph.D. degrees awarded in chemistry rose from 1551 in 1979–80 to 1622 in 1980–81 after having declined every year from 1970–71 through 1978–79.

Particularly impressive has been the increase in B.S. degrees awarded in chemical engineering. It has risen 81% from 3615 in 1970–71 to 6527 in 1980–81. Much of this gain has taken place since 1976–77.

Also noteworthy has been the rise in the number of Ph.D. degrees awarded in chemical engineering from 259 in 1977–78 to 300 in 1980–81—a gain of 16%. The latest available figure is still considerably lower, however, than the 406 Ph.D. degrees in chemical engineering awarded in 1970–71. Whether a tendency for more chemical engineers to obtain a Ph.D. degree is developing has yet to be determined. □

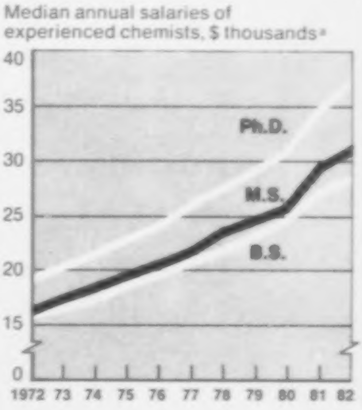
Salaries

Recession and inflation combine to crimp salaries this year for both experienced and inexperienced chemists

The long arm of business recession is having an impact on salaries of chemists, as well as on demand. The effect, moreover, is evident most clearly for chemists with no more than a bachelor's degree.

The median salary paid to all experienced chemists with a B.S. degree was up a mere 4% during the 12-month period ending last March. That's the smallest year-to-year gain in their earnings in the past six years. Annual salaries for chemists with higher degrees fared slightly better, but not much. The median for chemists with an M.S. climbed 5% and that for chemists with a Ph.D. was 7% higher between March 1981 and March 1982.

Chemists' salaries rose more slowly in 1982



[a] Chemists with more than 12 months of professional experience: data as of March of each year.
Source: ACS comprehensive salary survey

Even more unusual, however, is the 1% decline in the median starting salary for B.S. chemists that shows up this year. Not since the early 1970s have starting salaries dropped from the year before for chemists at any degree level. On the other hand, median starting salaries are up a healthy 12% in 1982 for inexperienced chemists with an M.S. and 10% for those who have earned a Ph.D.

These are some of the findings of two annual salary surveys carried out by the ACS Office of Manpower Studies. One survey, made last March (C&EN, July 5, page 22), deals with salaries of experienced chemists and chemical engineers who are ACS members. The other provides data on the salaries of inexperienced chemistry and chemical engineering graduates (those with 12 months or less of professional experience), many of whom are not ACS members. Results of this survey will be reported in November as Starting Salaries 1982.

The survey of experienced chemists and chemical engineers, based on responses from more than 12,000 ACS members, shows that the median annual salary of B.S. chemists increased from $27,500 on March 1, 1981, to $28,500 on March 1, 1982; the median annual salary of M.S. chemists rose from $30,000 to $31,600; and the median for Ph.D. chemists increased from $35,000 to $37,500.

The survey also found that the median annual salary of experienced B.S. chemical engineers who belong to ACS climbed 11% from $36,000 on March 1, 1981, to $40,000 on March 1, 1982; the median for M.S. chemical engineers rose 5% from $40,000 to $42,000; and that for Ph.D. chemical engineers rose 7% from $42,000 to $45,000.

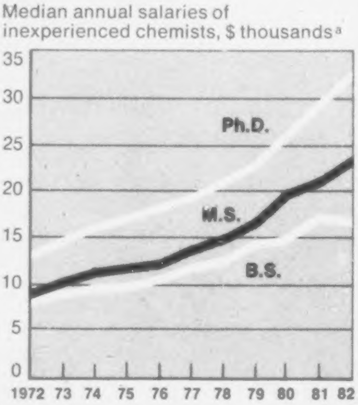
For chemical engineers covering all degree levels, the median annual salary increased 7% from $39,200 to $42,000, 21% greater than that of chemists.

The American Institute of Chemical Engineers tentatively reports that the median annual salary of its members (covering all degree levels) rose 15% from $34,000 in February 1981 to $39,000 in March 1982. As in the past, the median annual salary of AIChE members is lower than that of chemical engineers who belong to ACS. Members of AIChE, for one thing, on the average are younger and have less professional experience than ACS-member chemical engineers and are less likely to hold high-paying jobs in management.

Although between March 1981 and March 1982 the median salaries of chemists increased, no matter what degree they have, these gains evaporated as a result of inflation. Consumer prices, as measured by the Bureau of Labor Statistics, rose 7% during this period. Hence, the median salary of B.S. chemists in constant dollars declined 3% and that of M.S. chemists fell 1%, whereas the median for Ph.D. chemists remained, in effect, unchanged.

Chemists' salaries are influenced

Starting salaries decline slightly for B.S. chemists



[a] Chemists with 12 months or less of professional experience; data as of about June of each year.
Source: ACS starting salary surveys

by a variety of factors, including the type of employer they work for. Ph.D. chemists, for example, receive a median annual salary of $42,000 if they work in industry, $40,000 in government, and $30,000 in colleges and universities.

In March 1982, the median annual salary of B.S. chemists in industry was $30,600 for men and $23,000 for women. For M.S. chemists in industry, it was $35,000 for men and $27,350 for women. And for industrial Ph.D. chemists, it was $42,840 for men and $34,440 for women. Women chemists tend to earn less than men chemists in part because they are, on the average, younger and less experienced than men chemists. The median age of employed women belonging to ACS is 37, whereas it is 42 for men.

The 1982 ACS starting salary survey, which is reported here for the first time, is based on replies from 4436 inexperienced chemists and chemical engineers. It indicates that the median annual starting salary of B.S. chemists working full time is $17,000 this year, compared to $17,200 last year.

The median annual starting salary of M.S. chemists in 1982 rose to $23,880, from $21,300 in 1981. For Ph.D. chemists, it climbed to $32,400 from $29,500 in 1981.

As is typical, starting salaries of inexperienced chemical engineers surpass those of chemists. The median for B.S. chemical engineers working full time rose 9% from $24,400 in 1981 to $26,500 in 1982. The median for M.S. chemical engineers rose from $26,000 in 1981 to $28,800 in 1982, and for Ph.D. chemical engineers it increased from $31,500 to $35,000—a gain of 11% for both groups.

The medians for inexperienced full-time B.S. chemists in 1982 are $19,000 in manufacturing industry, $16,250 in nonmanufacturing industry, $14,840 in federal, state, and local governments, and $12,000 in colleges and universities. For full-time B.S. chemical engineers, the median starting salaries are $27,000 for those employed in manufacturing industry, $26,000 for those in nonmanufacturing industry, $19,930 for those in federal, state, and local governments, and $18,750 for those in colleges and universities.

In the past few years, median starting salaries of B.S. women chemists and chemical engineers in manufacturing industry either have exceeded those of their male counterparts or were similar. Earlier, the starting salaries of B.S. women chemists and chemical engineers were noticeably below those of men. This year, the median starting salary of B.S. women chemists is $18,920, whereas the median for comparable men is $19,000. In 1981, the median for B.S. women chemists was $19,000 and the median for men $18,000.

The median starting salary for B.S. chemical engineers who are women is $26,750 this year; for men it is $27,000. Last year, B.S. women chemical engineers received a median starting salary of $24,650, compared to $24,500 for B.S. men chemical engineers.

According to the ACS survey, 23% of inexperienced B.S. chemists are working full time in the chemical profession this year. Of the remainder, 26% have graduate assistantships or fellowships, 9% are employed full time in nonchemical jobs, 29% are unemployed but not seeking employment, and 13% are unemployed but seeking employment. Last year, only 10% of new B.S. chemists were unemployed but looking for a job.

Among inexperienced Ph.D. chemists in 1982, 63% are employed full time in the chemical profession, 31% have postdoctoral fellowships, 3% are doing nonchemical work, 1% are unemployed but not seeking employment, and 2% are unemployed but seeking employment. Last year, 1% of the new Ph.D. chemists were unemployed but in the job market.

The employment situation for Ph.D. chemists is appreciably better now than it was in the mid-1970s. In 1976, for example, only 44% of inexperienced Ph.D. chemists were employed full time in the chemical field. In addition, 49% of new Ph.D.s that year were doing postdoctoral work—in many cases, not because they wanted to but because they could not obtain other work. The proportion of new Ph.D. chemists doing postdoctoral work was as low as 24% in 1979.

Among new B.S. chemical engineers, 53% now are working full time in the chemical field, 9% have graduate assistantships or fellowships, 11% are employed full time in nonchemical work, 5% are unemployed but not seeking employment, and a sizable 23% are unemployed and seeking work. Only 7% of inexperienced B.S. chemical engineers were unemployed and seeking employment last year.

New Ph.D. chemical engineers have fared much better this year than those with B.S. degrees; 93% are employed full time in the chemical profession. Of the remainder, 4% are doing postdoctoral work, 2% are in nonchemical work, and 2% are unemployed but searching for a job. □

Salaries paid to professionals are difficult to compare

It is difficult to compare salaries earned by chemists with the salaries paid to other professionals. Strictly comparable data are not available for many types of work. Nevertheless, several organizations do compile salary information that provides a rough indication of what people earn in various fields.

The American Medical Association, for example, reports that the average net income (gross income, less expenses) of U.S. physicians from their medical practice in 1981 was $93,000. The American Dental Association estimates that the average net income of dentists from professional practice in 1981 was about $55,000. The American Institute of Physics says that the average salary of the Ph.D. members of the nine societies that constitute AIP (most of whose members are physicists and about 75% of whom are Ph.D.s) was $37,100 in May 1981.

Each year, the Department of Labor's Bureau of Labor Statistics gathers data on the salaries of employees in a number of white-collar occupations in private industry. BLS collects the information primarily to determine whether the salaries that the government pays its employees are competitive with those paid by industry. The findings permit general comparisons to be made between the salaries offered by industry to workers in various professions at different job levels.

	Average annual salary[a]
Attorneys, upper level	$76,202
Engineers, upper level	62,494
Chief accountants, upper level	61,255
Personnel directors, upper level	57,859
Chemists, upper level	53,658
Accountants, upper level	48,549
Chief accountants, starting	34,506
Engineers, middle level	34,443
Chemists, middle level	34,047
Personnel directors, starting	31,136
Attorneys, starting	25,162
Engineers, starting	23,622
Chemists, starting	19,640
Accountants, starting	18,260

a As of March 1982, excluding overtime and nonproduction bonuses, but including cost-of-living bonuses and incentive earnings. Source: Department of Labor's Bureau of Labor Statistics

BEST AVAILABLE COPY

Career Planning

Career Planning is designed to acquaint both the student and the experienced graduate with services, sources of information, and organizations that can supply guidance in selecting, obtaining, and changing careers. The directory included at the end of this section is a guide to U.S. organizations that employ significant numbers of chemists and chemical engineers. It is, of course, not all-inclusive. The directories listed under General Information include the names of other organizations that employ chemists and chemical engineers. Inquiries about career opportunities in specific organizations should be adressed directly to the organization, in care of the personnel director.

GENERAL INFORMATION

American Chemical Society: Chemical & Engineering News salary surveys, employment surveys, and classified ads (see also ACS Information below), 1155—16th St., N.W., Washington, D.C. 20036.

Directories: "American Council of Independent Laboratories Directory, 1982," 1725 K St., N.W., Washington, D.C. 20006; "Association of Consulting Chemists & Chemical Engineers Council Directory," 21st edition, 1982, 50 East 41st St., New York, N.Y. 10017; "College Placement Annual, 1983," College Placement Council, P.O. Box 2263, Bethlehem, Pa. 18801; "American Consulting Engineers Council Membership Directory, 1982-83," 1155—15th St., N.W., Washington, D.C. 20005; "Directory of Chemical Producers, 1982," SRI International, Menlo Park, Calif. 94025; "Industrial Research Laboratories of the United States," 17th edition, 1982, R. R. Bowker Co., 1180 Ave. of the Americas, New York, N.Y. 10036; "Research Centers Directory," 7th edition, 1982, Gale Research Co., Book Tower, Detroit, Mich. 48226.

Scientific Manpower Commission: "Science and Engineering Careers—A Bibliography," April 1974, $2.00; "Salaries of Scientists, Engineers, and Technicians," 10th edition, November 1981, $25; "Professional Women and Minorities—A Manpower Data Resource Service," 3rd edition, April 1982, $60; "Supply and Demand for Scientists and Engineers," 2nd edition, January 1982, $25; "Manpower Planning for Scientists and Engineers," May 1977, $2.00; *Scientific, Engineering, Technical Manpower Comments*, 10 issues a year, $30 for one year, $55 for two years. All available from 1776 Massachusetts Ave., N.W., Washington, D.C. 20036.

Scientific and professional societies: American Institute of Chemists, 7315 Wisconsin Ave., N.W., Washington, D.C. 20014; American Institute of Chemical Engineers, 345 East 47th St., New York, N.Y. 10017; and National Society of Professional Engineers, 2029 K St., N.W., Washington, D.C. 20006. They offer information on their specific programs for career guidance.

Sources of information about prospective employers: Available in many public libraries, "Moody's Industrial Manual," "Dun & Bradstreet," "Thomas Register of American Manufacturers," and "Standard and Poor's Register."

U.S. Department of Labor: Occupational Outlook Handbook, 1982-83 edition, Bulletin 2200, $13 per hardback copy and $9.00 per paperback copy. Order from Bureau of Labor Statistics, 1515 Broadway, New York, N.Y. 10036, or other office of the bureau.

Vocational guidance manuals: "Opportunities in Chemistry" by John H. Woodburn, 1979; "Opportunities in Engineering Technology" by John E. Heer Jr. and D. Joseph Hagerty, 1979; "Opportunities in Materials Science" by Charles Wert, 1978; "Opportunities in Energy Careers" by John H. Woodburn, 1979; "Opportunities in Environmental Careers" by Odom Fanning, 1981; "Opportunities in Chemical Engineering" by D. Joseph Hagerty, Earl R. Gerhard, and Charles A. Plank, 1979; and "Women in Science" by Alice Fins, 1979. Available from VGM Career Horizons, a division of National Textbook Co., 8259 Niles Center Rd., Skokie, Ill. 60077. "Peterson's Guide to Engineering, Science, and Computer Jobs," 1982 edition. Available from Peterson's Guides, P.O. Box 2123, Princeton, N.J. 08540.

ACS INFORMATION

Education aids for high school students: Careers in Chemistry: Questions and Answers," "List of ACS Approved Schools," "A Career in Chemical Engineering," "A Career in Analytical Chemistry," "A Career as a Chemical Technician," and "Financial Aids for College Students." All single copies free from ACS Education Marketing Office.

Education aids for college students: "College Chemistry Seniors," a listing of résumés submitted by seniors majoring in chemistry and chemical engineering who plan to enter graduate school, 1982-83 edition, $98; "Directory of Graduate Research," a listing of master's and Ph.D. degree-granting departments of chemistry, chemical engineering, biochemistry, and pharmaceutical/medicinal chemistry in the U.S. and Canada, with names of faculty members, their research interests, and bibliographies of their recent publications, 1981 edition, $37; and "College Chemistry Faculties," a listing of two- and four-year college and university teachers of chemistry, chemical engineering, and biochemistry in the U.S., Canada, and Mexico, 5th edition (1980), $25. All available from ACS Distribution Office. "Graduate School Information Aids," "Careers Nontraditional," "Career Options," "I Know You're a Chemist, But What Do You Do?," "Graduate Programs," and "Futures Through Chemistry: Charting a Course" are available from ACS Education Marketing Office, single copies free.

Journal of Chemical Education, a monthly publication of the ACS Division of Chemical Education, $17 per year for regular domestic individual subscribers and $12.75 per year for domestic students. Available from *Journal of Chemical Education*, Subscription Fulfillment Department, 20th & Northampton St., Easton, Pa. 18042.

Information for foreign students: "Guide to Chemical Education in the U.S. for Foreign Students" (paperback, 106 pages) recommends the eduational backgrounds students should have to study chemistry in the U.S. It discusses prerequisites that must be met in chemistry, physics, and mathematics and indicates typical course contents, textbooks in wide use, and representative examinations that students should be able to pass at different stages in work toward B.S., M.S., and Ph.D. degrees. Single copies are $7.50, and discounts are offered for bulk orders. Available from ACS Distribution Office.

Continuing education aids: ACS Short Courses are live, intensive, up-to-date courses in chemistry offered publicly year round, also available to organizations on an in-house basis; ACS Audio Courses, taped up-to-date courses by recognized authorities; ACS Video Courses, chemistry lectures on videotape; and ACS Computer Courses, highly interactive educational programs for chemists developed by experts for presentation on microcomputers. All available from ACS Education Division.

Employment information: ACS publishes several annual volumes of statistical data about the chemical profession and the salaries paid to its members: "Salaries 1982," the results of a salary survey of the ACS membership, 97 pages, $45; "Professionals in Chemistry 1979–1980," a statistical yearbook, 51 pages, $22; "Starting Salaries 1981," the results of a survey of new graduates in chemistry and chemical engineering, 75 pages, $10 (the 1982 edition will be available in early November for $10); and "Women Chemists 1980," a report on women chemists' salaries and employment, 140 pages, $10. All from ACS Distribution Office.

The 1978 edition of "Professional Employment Guidelines" is free; send stamped, self-addressed, business-size envelope. "Chemistry: A Job or a Career?" consists of a 30-minute cassette tape, booklets, and a slide presentation that are offered free to student affiliate chapters and to chemistry and chemical engineering departments. Available from ACS Department of Professional Relations & Manpower Studies.

Salary information in C&EN: Starting salaries in 1982, see page 50. Comprehensive salary survey in 1982, C&EN, July 5, page 22.

ACS EMPLOYMENT AIDS

Employment Clearing House: ACS members and student affiliates can file applications in the Washington office at no charge. Employers may write or call the Washington office to receive copies of résumés of applicants who possess specified qualifications for positions. The service is year-round and nonconfidential.

Confidential Employment Listing: This service enables employed ACS members who are seeking a new position to have their records on file at the ACS Employment Aids Office and to have them made available to all but specified employers, such as their present employer. This listing enables experienced candidates who otherwise would not wish to have their records circulated on a nonrestricted basis to let all but specified employers know of their desire to find a new position. Because of the added cost of handling such confidential records, ACS members are charged $25 for a year's listing.

Employment Clearing House, National Meetings: The society helps ACS members and employers to arrange on-the-spot interviews at ACS national meetings. This free, nonconfidential service is open to those registered and in attendance at the meeting. Unemployed members who want to use the national Employment Clearing House may have meeting registration fees waived on request.

Academic Openings: This publication lists positions, including postdoctoral positions, available at colleges and universities. It is published on a monthly basis if enough notices are received from academic institutions. The 20th of any month is the deadline for publication. If too few listings are received, publication is held over until the next month. This service is provided for all those interested in academic employment. Subscriptions to Academic Openings are $12 a year and can be obtained by writing to the ACS Employment Aids Office.

C&EN employment advertising section: Student affiliates and employed ACS members receive discounts from regular advertising rates. ACS members who are unemployed or are under notice of involuntary unemployment within 60 days may place one free classified "situations wanted" advertisement that will appear in every other issue for a period of six months—a total of 13 insertions a year. Student members or student affiliates who have not gained employment two months before graduation are entitled to the same privileges. Retired members are entitled to six free nondisplay advertisements a year. See the Employment Ads Information box at the start of the C&EN employment advertising section in any current issue for instructions.

Résumé service: An unemployed member may obtain free up to 50 printed copies of his or her résumé, limited to two pages typed in reproducible form. Write ACS Employment Aids Office.

ACS local sections: Some ACS local sections provide job assistance. Contact the secretary of the local section.

For ACS information listed in this section, write to American Chemical Society, 1155—16th St., N.W., Washington, D.C. 20036.

OTHER EMPLOYMENT SERVICES

Classified listings: *Chemical & Engineering News*, weekly newsmagazine of the American Chemical Society; *Chemical Engineering Progress*, monthly magazine of the American Institute of Chemical Engineers; *The Chemist*, monthly publication of the American Institute of Chemists; *Science*, weekly magazine of the American Association for the Advancement of Science; and classified sections of newspapers.

College placement bureaus: Campus placement offices usually maintain a file of openings for graduating students and recent graduates. They frequently arrange interviews between students and employers.

Private placement agencies: Check those in your area to determine what services are offered. They differ in quality, cost, and nature of service.

ORGANIZATIONS FOR WOMEN

American Association for the Advancement of Science: Project on Women in Science, Office of Opportunities in Science, AAAS, 1776 Massachusetts Ave., N.W., Washington, D.C. 20036.

American Association of University Professors: Committee on Status of Women in the Profession, AAUP, 1 Dupont Circle, N.W., Washington, D.C. 20036.

American Chemical Society: Women Chemists Committee, Maureen G. Chan, Room 7F-208, Bell Laboratories, 600 Mountain Ave., Murray Hill, N.J. 07974.

American Society of Biological Chemists: Committee on Equal Opportunities for Women, Elizabeth Anderson, ASBC, 9650 Rockville Pike, Bethesda, Md. 20014.

Association for Women in Science: Room 1122, 1346 Connecticut Ave., N.W., Washington, D.C. 20036.

Society of Women Engineers: Mary Lou Barnas, Executive Secretary, Room 305, 345 East 47th St., New York, N.Y. 10017.

Directory

The following list includes most of the nation's major employers of chemists and/or chemical engineers. The organizations did not ask to be included in this directory and are not necessarily hiring chemists or chemical engineers at this time.

Chemicals

Aceto Chemical Co., 126-02 Northern Blvd., Flushing, N.Y. 11368

Airco, 85 Chestnut Ridge Rd., Montvale, N.J. 07645 (subsidiary of BOC International Ltd. of the U.K.)

Air Products & Chemicals, P.O. Box 538, Allentown, Pa. 18105

Akzona, P.O. Box 2930, Asheville, N.C. 28802 (affiliated with Akzo N.V. of the Netherlands)

Alcolac, 3440 Fairfield Rd., Baltimore, Md. 21226

Aldrich Chemical Co., 940 West St. Paul Ave., Milwaukee, Wis. 53233

Allied Chemical Co., P.O. Box 1087R, Morristown, N.J. 07960 (division of Allied Corp.)

American Color & Chemical Corp., P.O. Box 32516, Charlotte, N.C. 28232 (subsidiary of North American Philips Corp. and Koppers Co.)

American Cyanamid Co., 1 Cyanamid Plaza, Wayne, N.J. 07470

American Enka Co., Enka, N.C. 28728 (division of Akzona)

American Hoechst Corp., Rte. 202-206 North, Somerville, N.J. 08876 (owned by Hoechst A.G. of West Germany)

American Hoechst Corp., industrial chemicals division, P.O. Box 268, Coventry, R.I. 02816

Amoco Chemicals Corp., 200 East Randolph Dr., Chicago, Ill. 60601 [subsidiary of Standard Oil Co. (Ind.)]

Ansul Co., 1 Stanton St., Marinette, Wis. 54143 (subsidiary of Wormald International of Australia)

Apex Chemical Corp., 200 South First St., Elizabethport, N.J. 07206

Arco Chemical Co., 1500 Market St., Philadelphia, Pa. 19101 (division of Atlantic Richfield Co.)

Arizona Chemical Co., 16-00 Rte. 208, Fair Lawn, N.J. 07410 (jointly owned by American Cyanamid Co. and International Paper Co.)

Armak Co., 300 South Wacker Dr., Chicago, Ill. 60606 (subsidiary of Akzona)

Ashland Chemical Co., P.O. Box 2219, Columbus, Ohio 43216 (subsidiary of Ashland Oil)

AZS Corp., P.O. Box 93366, Atlanta, Ga. 30318 (subsidiary of Toyo Soda Mfg. Co. of Japan)

Badische Corp., Williamsburg, Va. 23185 (subsidiary of BASF A.G. of West Germany)

J. T. Baker Chemical Co., 600 North Broad St., Phillipsburg, N.J. 08865 (subsidiary of Richardson-Vicks)

BASF Wyandotte Corp., 100 Cherry Hill Rd., Parsippany, N.J. 07054 (owned by BASF A.G. of West Germany)

Beaunit Corp., 261 Madison Ave., New York, N.Y. 10016 (subsidiary of El Paso Natural Gas Co.)

Betz Laboratories, 4636 Somerton Rd., Trevose, Pa. 19047

Big Three Industries, P.O. Box 3047, Houston, Tex. 77001

Borden Chemical, 180 East Broad St., Columbus, Ohio 43215 (division of Borden)

Borg-Warner Corp., 200 South Michigan Ave., Chicago, Ill. 60604

Buckman Laboratories, 1256 North McLean Blvd., Memphis, Tenn. 38108

Cabot Corp., 125 High St., Boston, Mass. 02110

Calbiochem-Behring Corp., 10933 North Torrey Pines Rd., La Jolla, Calif. 92037 (subsidiary of American Hoechst Corp.)

Calgon Corp., P.O. Box 1346, Pittsburgh, Pa. 15230 (subsidiary of Merck & Co.)

Callery Chemical Co., Callery, Pa. 16024 (division of Mine Safety Appliances Co.)

Carus Corp., 1500 Eighth St., La Salle, Ill. 61301

Celanese Corp., 1211 Ave. of the Americas, New York, N.Y. 10036

CF Industries, Salem Lake Dr., Long Grove, Ill. 60047

Chemed Corp., 1200 DuBois Tower, Cincinnati, Ohio 45202

Chemplex Co., 3100 Gold Rd., Rolling Meadows, Ill. 60008 (jointly owned by American Can Co. and Getty Oil Co.)

Chemtech Industries, 1655 Des Peres Rd., St. Louis, Mo. 63131

Chevron Chemical Co., 575 Market St., San Francisco, Calif. 94105 (subsidiary of Standard Oil Co. of California)

Ciba-Geigy Corp., Saw Mill River Rd., Ardsley, N.Y. 10502 (owned by Ciba-Geigy A.G. of Switzerland)

Clorox Co., 1221 Broadway, Oakland, Calif. 94612 (owned 23% by Henkel KGaA of West Germany)

Columbia Nitrogen Corp., P.O. Box 1483, Augusta, Ga. 30913 (owned by DSM N.V. of the Netherlands)

Cooperative Farm Chemicals Association, P.O. Box 308, Lawrence, Kan. 66044 (owned by Farmland Industries and Missouri Farmers Association)

Copolymer Rubber & Chemical Corp., P.O. Box 2591, Baton Rouge, La. 70821

Crompton & Knowles Corp., chemicals group, Rte. 208, Fair Lawn, N.J. 07410

Cyclo Chemicals Corp., 7500 North West 66th St., Miami, Fla. 33166

Dart Industries, P.O. Box 3157, Terminal Annex, Los Angeles, Calif. 90051 (subsidiary of Dart & Kraft)

Daubert Chemical Co., 1200 Jorie Blvd., Oak Brook, Ill. 60521

Dearborn Chemical, 300 Genesee St., Lake Zurich, Ill. 60047 (division of Chemed Corp.)

Detrex Chemical Industries, 4000 Town Ctr., Southfield, Mich. 48075

Dexter Chemical Corp., 845 Edgewater Rd., Bronx, N.Y. 10474

Dexter Corp., 1 Elm St., Windsor Locks, Conn. 06096

Diamond Shamrock Corp., 2300 Southland Ctr., Dallas, Tex. 75201

Diversey Wyandotte Corp., 1532 Biddle Ave., Wyandotte, Mich. 48192

Dixie Chemical Co., P.O. Box 13410, Houston, Tex. 77019

Dow Chemical U.S.A., 2020 Dow Ctr., Midland, Mich. 48640

Dow Corning Corp., P.O. Box 1767, Midland, Mich. 48640 (jointly owned by Dow Chemical Co. and Corning Glass Works)

Drew Chemical Corp., 1 Drew Chemical Plaza, Boonton, N.J. 07005 (subsidiary of U.S. Filter Corp.)

DuBois Chemicals, 1314 DuBois Tower, Cincinnati, Ohio 45202 (division of Chemed Corp.)

E. I. du Pont de Nemours & Co., 1007 Market St., Wilmington, Del. 19898

Eagle-Picher Industries, 580 Walnut St., Cincinnati, Ohio 45202

Eastern Chemical division, P.O. Box 2500, Smithtown, N.Y. 11787 (division of Guardian Chemical Corp.)

Eastman Chemical Products, P.O. Box 431, Kingsport, Tenn. 37662 (subsidiary of Eastman Kodak Co.)

Economics Laboratory, 370 Wabasha St., St. Paul, Minn. 55102

Emery Industries, 1300 Carew Tower, Cincinnati, Ohio 45202 (subsidiary of National Distillers & Chemical Corp.)

Emkay Chemical Co., 319-325 Second St., Elizabeth, N.J. 07206

Essex Chemical Corp., 1401 Broad St., Clifton, N.J. 07015

Ethyl Corp., 330 South Fourth St., Richmond, Va. 23219

Exxon Chemical Co., 1251 Ave. of the Americas, New York, N.Y. 10020 (division of Exxon Corp.)

Fairmount Chemical Co., 117 Blanchard St., Newark, N.J. 07105

Farmland Industries, P.O. Box 7305, Kansas City, Mo. 64116

Ferro Corp., 1 Erieview Plaza, Cleveland, Ohio 44114

Fiber Industries, P.O. Box 32414, Charlotte, N.C. 28232 (jointly owned by Celanese Corp. and Imperial Chemical Industries of the U.K.)

Filtrol Corp., 5959 West Century Blvd., Los Angeles, Calif. 90045 (subsidiary of U.S. Filter Corp.)

Firestone Synthetic Fibers Co., P.O. Box 450, Hopewell, Va. 23860 (division of Firestone Tire & Rubber Co.)

First Chemical Corp., P.O. Box 1427, Pascagoula, Miss. 39567 (subsidiary of First Mississippi Corp.)

Fisher Scientific Co., 711 Forbes Ave., Pittsburgh, Pa. 15219 (subsidiary of Allied Corp.)

FMC Corp., 200 East Randolph Dr., Chicago, Ill. 60601

FMC Corp., industrial chemical group, 2000 Market St., Philadelphia, Pa. 19103

Frank Enterprises, 700 Rose Ave., Columbus, Ohio 43219

Fritzsche Dodge & Olcott, 76 Ninth Ave., New York, N.Y. 10011 (owned by BASF A.G. of West Germany)

GAF Corp., 140 West 51st St., New York, N.Y. 10020

General Electric Co., engineered materials group, 500 West Wilson Bridge Rd., Columbus, Ohio 43285

General Electric Co., plastics business operations, 1 Plastics Ave., Pittsfield, Mass. 01201

General Latex & Chemical Corp., 666 Main St., Cambridge, Mass. 02139

General Tire & Rubber Co., chemicals/plastics/industrial products division, 1 General St., Akron, Ohio 44329

Georgia-Pacific Corp., 900 South West Fifth Ave., Portland, Ore. 97204

Givaudan Corp., 100 Delawanna Ave., Clifton, N.J. 07014 (an affiliate of L. Givaudan & Cie. of Switzerland)

Glyco, P.O. Box 700, Greenwich, Conn. 06836

B. F. Goodrich Co., chemical group, 6100 Oak Tree Blvd., Cleveland, Ohio 44131

Goodyear Tire & Rubber Co., chemical division, 1144 East Market St., Akron, Ohio 44316

W. R. Grace & Co., 1114 Ave. of the Americas, New York, N.Y. 10036 (owned 28% by Flick Group of West Germany)

Great Lakes Carbon Corp., 299 Park Ave., New York, N.Y. 10017

Great Lakes Chemical Corp., P.O. Box 2200, West Lafayette, Ind. 47906

Great Salt Lake Minerals & Chemicals Corp., P.O. Box 1190, Ogden, Utah 84402 (subsidiary of Gulf Resources & Chemical Corp.)

Grow Group, 200 Park Ave., New York, N.Y. 10017

GTE Products Corp., 1 Stamford Forum, Stamford, Conn. 06904 (division of General Telephone & Electronics Corp.)

Guardian Chemical Corp., P.O. Box 2590, Smithtown, N.Y. 11787

Gulf Oil Chemicals Co., P.O. Box 3766, Houston, Tex. 77253 (division of Gulf Oil Corp.)

C. P. Hall Co., 7300 South Central Ave., Chicago, Ill. 60638

Harshaw Chemical Co., 1945 East 97th St., Cleveland, Ohio 44106 (subsidiary of Gulf Oil Corp.)

Henkel Corp., 4620 West 77th St., Minneapolis, Minn. 55435 (owned by Henkel KGaA of West Germany)

Hercules, 910 Market St., Wilmington, Del. 19899

Hilton-Davis Chemical Co., 2235 Langdon Farm Rd., Cincinnati, Ohio 45237 (division of Sterling Drug)

Hitco, 1600 West 135th St., Gardena, Calif. 90249 (subsidiary of Armco)

Hoechst Fibers Industries, 1515 Broadway, New York, N.Y. 10036 (division of American Hoechst Corp.)

Humphrey Chemical Co., Devine St., North Haven, Conn. 06473

Philip A. Hunt Chemical Corp., Roosevelt Pl., Palisades Park, N.J. 07650 (partly owned by Turner & Newall Ltd. of the U.K.)

ICI Americas, Wilmington, Del. 19897 (owned by Imperial Chemical Industries of the U.K.)

IMC Chemical Group, 666 Garland Pl., Des Plaines, Ill. 60016 (subsidiary of International Minerals & Chemical Corp.)

Inmont Corp., 1255 Bird St., Clifton, N.J. 07011 (subsidiary of United Technologies Corp.)

International Flavors & Fragrances, 521 West 57th St., New York, N.Y. 10019

International Minerals & Chemical Corp., 2315 Sanders Rd., Northbrook, Ill. 60062

Kaiser Industrial Chemicals, 300 Lakeside Dr., Oakland, Calif. 94643 (division of Kaiser Aluminum & Chemical Corp.)

Kay-Fries, 200 Summit Ave., Montvale, N.J. 07645 (owned 75% by Dynamit Nobel A.G. of West Germany and 25% by Tennants Consolidated Ltd. of the U.K.)

Kerr-McGee Chemical Corp., Kerr-McGee Ctr., Oklahoma City, Okla. 73125 (subsidiary of Kerr-McGee Corp.)

Koppers Co., Koppers Bldg Pittsburgh, Pa. 15219

Lawter International, 990 Skokie Blvd., Northbrook, Ill. 60062

Liquid Air Corp., 1 Embarcadero Ctr., San Francisco, Calif. 94111

Liquid Carbonic Corp., 135 South La Salle St., Chicago, Ill. 60603 (subsidiary of Houston Natural Gas Corp.)

Lithium Corp. of America, 449 North Cox Rd., Gastonia, N.C. 28052 (subsidiary of Gulf Resources & Chemical Corp.)

Lonza, 22-10 Rte. 208, Fair Lawn, N.J. 07410 (owned by Lonza A.G. of Switzerland)

Lubrizol Corp., 29400 Lakeland Blvd., Wickliffe, Ohio 44092

MacKenzie Chemical Works, 1 Cordello Ave., Central Islip, N.Y. 11722

MacKenzie Intervar, P.O. Box 219, Bush, La. 70431 (part of MacKenzie Chemical Works)

Mallinckrodt, P.O. Box 5840, St. Louis, Mo. 63134

Millmaster Onyx Group, 99 Park Ave., New York, N.Y. 10016 (subsidiary of Gulf Oil Corp.)

Mobay Chemical Corp., Penn Lincoln Pkwy. West, Pittsburgh, Pa. 15205 (owned by Bayer A.G. of West Germany)

Mobil Chemical Co., 150 East 42nd St., New York, N.Y. 10017 (division of Mobil Oil Corp.)

Monsanto Co., 800 North Lindbergh Blvd., St. Louis, Mo. 63166

Morton Chemical Division, 2 North Riverside Plaza, Chicago, Ill. 60606 (division of Morton-Norwich Products)

Morton-Norwich Products, 110 North Wacker Dr., Chicago, Ill. 60606

M&T Chemicals, Woodbridge Rd. & Randolph Ave., Rahway, N.J. 07065 (subsidiary of Texasgulf)

Nalco Chemical Co., 2901 Butterfield Rd., Oak Brook, Ill. 60521

National Distillers & Chemical Corp., 99 Park Ave., New York, N.Y. 10016

National Starch & Chemical Corp., 10 Finderne Ave., Bridgewater, N.J. 08807 (owned by Unilever of the U.K.)

Neville Chemical Co., Neville Island, Pittsburgh, Pa. 15225

New England Nuclear Corp., 549 Albany St., Boston, Mass. 02118 (subsidiary of Du Pont)

NL Chemicals, P.O. Box 700, Hightstown, N.J. 08520 (division of NL Industries)

Northern Petrochemical Co., 2223 Dodge St., Omaha, Neb. 68102 (subsidiary of InterNorth)

Norton Chemical Process Products division, 12 East Ave., Tallmadge, Ohio 44278 (division of Norton Co.)

Noury Chemical Corp., 2153 Lockport-Olcott Rd., Burt, N.Y. 14028 (subsidiary of Armak Co.)

Occidental Chemical Corp., 1980 Post Oak Blvd., Houston, Tex. 77056 (subsidiary of Occidental Petroleum Corp.)

Olin Corp., 120 Long Ridge Rd., Stamford, Conn. 06904

Ozark-Mahoning Co., 1870 South Boulder Ave., Tulsa, Okla. 74119 (subsidiary of Pennwalt Corp.)

Pantasote, 26 Jefferson St., Passaic, N.J. 07055

Pearsall Chemical division, P.O. Box 437, Houston, Tex. 77001 (division of Witco Chemical Corp.)

Penick Corp., 1050 Wall St. West, Lyndhurst, N.J. 07071 (unit of CPC International)

Pennwalt Corp., 3 Pkwy., Philadelphia, Pa. 19102

Petrolite Corp., 100 North Broadway, St. Louis, Mo. 63102

Petro-Tex Chemical Corp., 8600 Park Place Blvd., Houston, Tex. 77017 (subsidiary of Tenneco)

Pfanstiehl Laboratories, 1219 Glen Rock Ave., Waukegan, Ill. 60085

Pfister Chemical, Linden Ave., Ridgefield, N.J. 07657

Phillips Petrochemicals Division, 15 Phillips Bldg., Bartlesville, Okla. 74004 (division of Phillips Petroleum Co.)

Phillips Fibers Corp., P.O. Box 66, Greenville, S.C. 29602 (subsidiary of Phillips Petroleum Co.)

Pierce Chemical Co., P.O. Box 117, Rockford, Ill. 61105

Polychrome Corp., P.O. Box 817, Yonkers, N.Y. 10702 (owned by Dainippon Ink & Chemicals of Japan)

PPG Industries, 1 Gateway Ctr., Pittsburgh, Pa. 15222

PQ Corp., P.O. Box 840, Valley Forge, Pa. 19482

Procter & Gamble Co., P.O. Box 599, Cincinnati, Ohio 45201

Publicker Industries, 777 West Putnam Ave., Greenwich, Conn. 06836

PVO International, World Trade Ctr., San Francisco, Calif. 94111 (subsidiary of Kay Corp.)

Quaker Oats Co., chemicals division, P.O. Box 3514, Chicago, Ill. 60654

Reichhold Chemicals, 523 North Broadway, White Plains, N.Y. 10603

Reilly Tar & Chemical Corp., 151 North Delaware St., Indianapolis, Ind. 46204

Rhône-Poulenc, 52 Vanderbilt Ave., New York, N.Y. 10017 (subsidiary of Rhône-Poulenc S.A. of France)

Richardson Co., 2400 East Devon Ave., Des Plaines, Ill. 60018

Rilsan Corp., 139 Harristown Rd., Glen Rock, N.J. 07452 (owned by ATO Chimie S.A. of France)

Ritter International, 4001 Goodwin Ave., Los Angeles, Calif. 90039

Riverdale Chemical Co., 220 East 17th St., Chicago Heights, Ill. 60411

Rohm & Haas Co., Independence Mall West, Philadelphia, Pa. 19105

R.S.A. Corp., 690 Saw Mill River Rd., Ardsley, N.Y. 10502

Rubicon Chemicals, P.O. Box 751, Wilmington, Del. 19897 (subsidiary of ICI Americas)

Sandoz, Rte. 10, East Hanover, N.J. 07936 (owned by Sandoz A.G. of Switzerland)

SCM Corp., 299 Park Ave., New York, N.Y. 10017

Shell Chemical Co., P.O. Box 2463, Houston, Tex. 77001 (division of Shell Oil Co.)

Shepherd Chemical Co., 4900 Beech St., Cincinnati, Ohio 45212

Stauffer Chemical Co., Nyala Farm Rd., Westport, Conn. 06881

Stepan Chemical Co., Edens & Winnetka Rd., Northfield, Ill. 60093

Sterling Organics, 90 Park Ave., New York, N.Y. 10016 (division of Sterling Drug)

Sun Chemical Corp., 200 Park Ave., New York, N.Y. 10017

Sybron Corp., 1100 Midtown Towers, Rochester, N.Y. 14604

Tenneco Chemicals, Park 80 Plaza West, Saddle Brook, N.J. 07662 (division of Tenneco)

Texaco Chemical Co., P.O. Box 430, Bellaire, Tex. 77401 (division of Texaco)

Texasgulf, High Ridge Park, Stamford, Conn. 06904 (owned by Société Nationale Elf-Aquitaine S.A. of France)

TH Agriculture & Nutrition Co., P.O. Box 2700, Kansas City, Kan. 66110 (subsidiary of North American Philips Corp.)

Thompson-Hayward Chemical Co., P.O. Box 2383, Kansas City, Kan. (member of the Harrisons & Crosfield Group of the U.K.)

Toms River Chemical Corp., P.O. Box 71, Toms River, N.J. 08753 (subsidiary of Ciba-Geigy Corp.)

Union Carbide Corp., Old Ridgebury Rd., Danbury, Conn. 06817

Union Chemicals division, 461 South Boylston St., Los Angeles, Calif. 90017 (division of Union Oil Co. of California)

Uniroyal Chemical, Spencer St., Naugatuck, Conn. 06770 (division of Uniroyal)

United Nuclear Corp., 7700 Leesburg Pike, Falls Church, Va. 22043 (subsidiary of UNC Resources)

U.S. Borax & Chemical Corp., 3075 Wilshire Blvd., Los Angeles, Calif. 90010 (owned by Rio Tinto Zinc Corp. of the U.K.)

U.S. Industrial Chemicals Co., 99 Park Ave., New York, N.Y. 10016 (division of National Distillers & Chemical Corp.)

USM Corp., 426 Colt Hwy., Farmington, Conn. 06032 (subsidiary of Emhart Corp.)

USS Chemicals, 600 Grant St., Pittsburgh, Pa. 15230 (division of U.S. Steel Corp.)

USS Novamont, 600 Grant St., Pittsburgh, Pa. 15230 (subsidiary of U.S. Steel Corp.)

Vanderbilt Chemical Corp., 30 Winfield St., Norwalk, Conn. 06855 (subsidiary of R. T. Vanderbilt Co.)

Velsicol Chemical Corp., 341 East Ohio St., Chicago, Ill. 60611 (subsidiary of Northwest Industries)

Ventron division, 150 Andover St., Danvers, Mass. 01923 (division of Thiokol Corp.)

Virginia Chemicals, 3340 West Norfolk Rd., Portsmouth, Va. 23703 (subsidiary of Celanese Corp.)

Vistron Corp., Midland Bldg., Cleveland, Ohio 44115 [subsidiary of Standard Oil Co. (Ohio)]

Vulcan Materials Co., P.O. Box 7497, Birmingham, Ala. 35253

West Agro-Chemical, P.O. Box 1386, Shawnee, Kan. 66222 (subsidiary of West Chemical Products)

West Chemical Products, 1000 Herrontown Rd., Princeton, N.J. 08540

Williams Cos., 1 Williams Ctr., Tulsa, Okla. 74103

Witco Chemical Corp., 277 Park Ave., New York, N.Y 10017

Drugs

Abbott Laboratories, 1400 Sheridan Rd., North Chicago, Ill. 60064

American Home Products Corp., 685 Third Ave., New York, N.Y. 10017

Armour Pharmaceutical Co., 303 South Broadway, Tarrytown, N.Y. 10591 (subsidiary of Revlon)

Astra Pharmaceutical Products, P.O. Box 1089, Framingham, Mass. 01701

Ayerst Laboratories, 685 Third Ave., New York, N.Y. 10017 (division of American Home Products Corp.)

Baxter Travenol Laboratories, 1 Baxter Pkwy., Deerfield, Ill. 60015

Breon Laboratories, 90 Park Ave., New York, N.Y. 10016 (subsidiary of Sterling Drug)

Bristol Laboratories, P.O. Box 657, Syracuse, N.Y. 13201 (division of Bristol-Myers Co.)

Bristol-Myers Co., 345 Park Ave., New York, N.Y. 10022

Burroughs Wellcome Co., 3030 Cornwallis Rd., Research Triangle Park, N.C. 27709 (owned by Wellcome Foundation Ltd. of the U.K.)

Carter-Wallace, 767 Fifth Ave., New York, N.Y. 10022

Ciba-Geigy Corp., pharmaceuticals division, 556 Morris Ave., Summit, N.J. 07901 (owned by Ciba-Geigy A.G. of Switzerland)

Cooper Laboratories, 3145 Porter Dr., Palo Alto, Calif. 94304

Cutter Laboratories, Fourth and Parker St., Berkeley, Calif. 94710 (owned by Bayer A.G. of West Germany)

Dorsey Laboratories, P.O. Box 63288, Lincoln, Neb. 68501 (division of Sandoz of Switzerland)

Endo Laboratories, 1000 Stewart Ave., Garden City, N.Y. 11530 (subsidiary of Du Pont)

Ethicon, U.S. Hwy. 22, Somerville, N.J. 08876 (subsidiary of Johnson & Johnson)

Ganes Chemicals, 1114 Ave. of the Americas, New York, N.Y. 10036 (owned by Siegfried A.G. of Switzerland)

Hoechst-Roussel Pharmaceuticals, Rte. 202-206 North, Somerville, N.J. 08876 (subsidiary of American Hoechst)

Hoffmann-La Roche, 340 Kingsland St., Nutley, N.J. 07110 (owned by F. Hoffmann-La Roche & Co. A.G. of Switzerland)

ICN Pharmaceuticals, 2727 Campus Dr., Irvine, Calif. 92664

Lederle Laboratories, Middletown Rd., Pearl River, N.Y. 10965 (division of American Cyanamid Co.)

Eli Lilly & Co., 307 East McCarty St., Indianapolis, Ind. 46285

Marion Laboratories, 10236 Bunker Ridge Rd., Kansas City, Mo. 64137

McNeil Laboratories, Camp Hill Rd., Fort Washington, Pa. 19034 (affiliate of Johnson & Johnson)

Mead Johnson & Co., 2400 Pennsylvania St., Evansville, Ind. 47721 (subsidiary of Bristol-Myers Co.)

Merck & Co., P.O. Box 2000, Rahway, N.J. 07065

Merrell Dow Pharmaceuticals, 2110 East Galbraith Rd., Cincinnati, Ohio 45215 (subsidiary of Dow Chemical Co.)

Miles Laboratories, P.O. Box 40, Elkhart, Ind. 46515 (owned by Bayer A.G. of West Germany)

Norwich-Eaton Pharmaceuticals, 17 Eaton Ave., Norwich, N.Y. 13815 (division of Procter & Gamble)

Organon, 375 Mt. Pleasant Ave., West Orange, N.J. 07052 (division of Akzona)

Ortho Pharmaceutical Corp., Raritan, N.J. 08869 (division of Johnson & Johnson)

Parke-Davis, P.O. Box 118, G.P.O., Detroit, Mich. 48232 (division of Warner-Lambert Co.)

Pfizer, 235 East 42nd St., New York, N.Y. 10017

Philips Roxane Laboratories, P.O. Box 16532, Columbus, Ohio 43216 (division of Boehringer Ingelheim Ltd. of West Germany)

Purdue Frederick Co., 50 Washington St., Norwalk, Conn. 06856

Rachelle Laboratories, 700 Henry Ford Ave., Long Beach, Calif. 90801 (subsidiary of International Rectifier Corp.)

Richardson-Vicks, 10 Westport Rd., Wilton, Conn. 06897

Riker Laboratories, 19901 Nordhoff St., Northridge, Calif. 91324 (subsidiary of 3M Co.)

A. H. Robins Co., 1407 Cummings Dr., Richmond, Va. 23220

Wm. H. Rorer, 500 Virginia Dr., Fort Washington, Pa. 19034 (subsidiary of Rorer Group)

Sandoz Pharmaceuticals, Rte. 10, East Hanover, N.J. 07936 (owned by Sandoz of Switzerland)

R. P. Scherer Corp., 2075 West Big Beaver St., Troy, Mich. 48084

Schering-Plough Corp., P.O. Box 500, Kenilworth, N.J. 07033

G. D. Searle & Co., P.O. Box 1045, Skokie, Ill. 60076

Smith Kline & French Laboratories, 1500 Spring Garden St., Philadelphia, Pa. 19101 (division of SmithKline Beckman Corp.)

Squibb Corp., 40 West 57th St., New York, N.Y. 10019

Sterling Drug, 90 Park Ave., New York, N.Y. 10016

Stuart Pharmaceuticals, New Murphy Rd. and Concord Pike, Wilmington, Del. 19897 (division of ICI Americas)

Syntex Corp., 3401 Hillview Ave., Palo Alto, Calif. 94304

Upjohn Co., 7000 Portage Rd., Kalamazoo, Mich. 49001

USV Pharmaceutical Corp., 1 Scarsdale Rd., Tuckahoe, N.Y. 10707 (division of Revlon)

Wallace Laboratories, Half Acre Rd., Cranbury, N.J. 08512 (division of Carter-Wallace)

Warner-Lambert Co., 201 Tabor Rd., Morris Plains, N.J. 07950

Westwood Pharmaceuticals, 468 Dewitt St., Buffalo, N.Y. 14213 (division of Bristol-Myers Co.)

Winthrop Laboratories, 90 Park Ave., New York, N.Y. 10016 (division of Sterling Drug)

Wyeth Laboratories, P.O. Box 8299, Philadelphia, Pa. 19101 (division of American Home Products Corp.)

Personal-care products

Alberto-Culver Co., 2525 Armitage Ave., Melrose Park, Ill. 60160

Avon Products, 9 West 57th St., New York, N.Y. 10019

Chesebrough-Ponds, 33 Benedict Pl., Greenwich, Conn. 06830

Clairol, 345 Park Ave., New York, N.Y. 10154 (subsidiary of Bristol-Myers Co.)

Colgate-Palmolive Co., 300 Park Ave., New York, N.Y. 10022

Fabergé, 1345 Ave. of the Americas, New York, N.Y. 10019

Max Factor & Co., 1655 McCadden Pl., Hollywood, Calif. 90028 (subsidiary of Norton Simon)

Gillette Co., Prudential Tower Bldg., Boston, Mass. 02199

Andrew Jergens Co., 2535 Spring Grove Ave., Cincinnati, Ohio 45214 (subsidiary of American Brands)

Lever Brothers Co., 390 Park Ave., New York, N.Y. 10022 (owned by Unilever of the U.K.)

Noxell Corp., P.O. Box 1799, Baltimore, Md. 21203

Purex Corp., 5101 Clark Ave., Lakewood, Calif. 90712

Revlon, 767 Fifth Ave., New York, N.Y. 10022

Shulton, 697 U.S. Hwy. 46, Clifton, N.J. 07015 (subsidiary of American Cyanamid Co.)

Coatings

Cook Paint & Varnish Co., P.O. Box 389, Kansas City, Mo. 64141

DeSoto, 1700 South Mt. Prospect Rd., Des Plaines, Ill. 60018

Dutch Boy, 2325 Hollins Ferry Rd., Baltimore, Md. 21230 (division of Sherwin-Williams Co.)

Glidden Coatings & Resins, 900 Union Commerce Tower, Cleveland, Ohio 44115 (division of SCM Corp.)

Guardsman Chemicals, 1350 Steele Ave., S.W., Grand Rapids, Mich. 49507

Lilly Industrial Coatings, P.O. Box 946, Indianapolis, Ind. 46206

Benjamin Moore & Co., 51 Chestnut Ridge Rd., Montvale, N.J. 07645

O'Brien Corp., 450 East Grand Ave., South San Francisco, Calif. 94080

Porter Paint Co., 13th & Walnut St., Louisville, Ky. 40201

Pratt & Lambert, P.O. Box 22, Buffalo, N.Y. 14240

Rust-Oleum Corp., 11 Hawthorn Pkwy., Vernon Hills, Ill. 60061

Sherwin-Williams Co., 101 Prospect Ave., Cleveland, Ohio 44115

Sinclair Paint Co., 2500 South Atlantic Blvd., Los Angeles, Calif. 90040 (division of Insilco Corp.)

Sinnett Industrial Coatings, 1380 Kingsland Ave., St. Louis, Mo. 63133

Valspar Corp., 1101 Third St. South, Minneapolis, Minn. 55415

Petroleum

Amerada Hess Corp., 1 Hess Plaza, Woodbridge, N.J. 07095

American Petrofina, P.O. Box 2159, Dallas, Tex. 75221

Ashland Oil, P.O. Box 391, Ashland, Ky. 41101

Atlantic Richfield Co., 515 South Flower St., Los Angeles, Calif. 90071

Cities Service Co., P.O. Box 300, Tulsa, Okla. 74102

Clark Oil & Refining Corp., 8530 West National Ave., Milwaukee, Wis. 53227

Conoco, High Ridge Park, Stamford, Conn. 06905 (subsidiary of Du Pont)

Cosden Oil & Chemical Co., P.O. Box 410, Dallas, Tex. 75221 (subsidiary of American Petrofina)

Exxon Corp., 1251 Ave. of the Americas, New York, N.Y. 10020

Getty Oil Co., 3810 Wilshire Blvd., Los Angeles, Calif. 90054

Gulf Oil Corp., P.O. Box 1166, Pittsburgh, Pa. 15230

Kerr-McGee Corp., Kerr-McGee Ctr., Oklahoma City, Okla. 73125

Marathon Oil Co., 539 South Main St., Findlay, Ohio 45840 (subsidiary of U.S. Steel Corp.)

Marathon Petroleum Co., 539 South Main St., Findlay, Ohio 45840 (subsidiary of Marathon Oil Co.)

Mobil Oil Corp., 150 East 42nd St., New York, N.Y. 10017

Murphy Oil Corp., 200 Jefferson Ave., El Dorado, Ark. 71730

Occidental Petroleum Corp., 10889 Wilshire Blvd., Los Angeles, Calif. 90024

Pennzoil Co., P.O. Box 2967, Houston, Tex. 77001

Phillips Petroleum Co., Phillips Bldg., Bartlesville, Okla. 74004

Quaker State Oil Refining Corp., 255 Elm St., Oil City, Pa. 16301

Shell Oil Co., 1 Shell Plaza, Houston, Tex. 77001

Standard Oil Co. of California, 225 Bush St., San Francisco, Calif. 94104

Standard Oil Co. (Ind.), 200 East Randolph Dr., Chicago, Ill. 60601

Standard Oil Co. (Ohio), Midland Bldg., Cleveland, Ohio 44115 (owned 53% by BP Ltd. of the U.K.)

Sun Co., 240 Radnor-Chester Rd., St. Davids, Pa. 19087

Tenneco, P.O. Box 2511, Houston, Tex. 77001

Texaco, 2000 Westchester Ave., White Plains, N.Y. 10650

Union Oil Co. of California, 461 South Boylston St., Los Angeles, Calif. 90017

Rubber

American Biltrite, 575 Technology Sq., Cambridge, Mass. 02139

Armstrong Rubber Co., 500 Sargent Dr., New Haven, Conn. 06507

Carlisle Corp., 1700 DuBois Tower, Cincinnati, Ohio 45202

Cooper Tire & Rubber Co., Lima and Western Ave., Findlay, Ohio 45840

Firestone Tire & Rubber Co., 1200 Firestone Pkwy., Akron, Ohio 44317

Gates Rubber Co., 999 South Broadway, Denver, Colo. 80217

General Tire & Rubber Co., 1 General St., Akron, Ohio 44329

B. F. Goodrich Co., 500 South Main St., Akron, Ohio 44318

Goodyear Tire & Rubber Co., 1144 East Market St., Akron, Ohio 44316

Mohawk Rubber Co., 50 Executive Pkwy., Hudson, Ohio 44236

St. Clair Rubber Co., P.O. Box 566, St. Clair Shores, Mich. 48080

Uniroyal, Oxford Management & Research Ctr., Middlebury, Conn. 06749

Paper and forest products

Bemis Co., 800 Northstar Ctr., Minneapolis, Minn. 55402

Boise Cascade Corp., 1 Jefferson Sq., Boise, Idaho 83728

Champion International Corp., 1 Landmark Sq., Stamford, Conn. 06921

Consolidated Papers, First Ave. North, Wisconsin Rapids, Wis. 54494

Container Corp. of America, 1 First National Plaza, Chicago, Ill. 60603 (subsidiary of Mobil Oil Corp.)

Continental Forest Industries, 21 Harbor Plaza, Stamford, Conn. 06904 (member of Continental Group)

Crown Zellerbach Corp., 1 Bush St., San Francisco, Calif. 94104

Diamond International Corp., 733 Third Ave., New York, N.Y. 10017

Georgia-Pacific Corp., 900 South West Fifth Ave., Portland, Ore. 97204

Great Northern Nekoosa Corp., 75 Prospect St., Stamford, Conn. 06901

Hammermill Paper Co., 1442 East Lake Rd., Erie, Pa. 16533

Inland Container Corp., 151 North Delaware St., Indianapolis, Ind. 46206

International Paper Co., P.O. Box 973, Wall St. Station, New York, N.Y. 10268

ITT Rayonier, 1177 Summer St., Stamford, Conn. 06904 (subsidiary of International Telephone & Telegraph Corp.)

Kimberly-Clark Corp., 128 North Lake St., Neenah, Wis. 54956

Mead Corp., Courthouse Plaza, Northeast, Dayton, Ohio 45463

Potlatch Corp., 1 Maritime Plaza, San Francisco, Calif. 94111

Procter & Gamble Paper Products Co., P.O. Box 866, Oxnard, Calif. 93032

St. Regis Paper Co., 150 East 42nd St., New York, N.Y. 10017

Scott Paper Co., Scott Plaza, Philadelphia, Pa. 19113

Union Camp Corp 1600 Valley Rd., Wayne, N.J. 07470

Westvaco Corp., 299 Park Ave., New York, N.Y. 10017

Weyerhaeuser Co., Tacoma, Wash. 98477

Metals and minerals

Allegheny International, 2 Oliver Plaza, Pittsburgh, Pa. 15222

Allied-Kelite Products division, 2400 East Devon Ave., Des Plaines, Ill. 60018 (division of Richardson Co.)

Aluminum Co. of America, 1501 Alcoa Bldg., Pittsburgh, Pa. 15219

Amax, Amax Ctr., Greenwich, Conn. 06836

Anaconda Co., 555—17th St., Denver, Colo. 80271 (subsidiary of Atlantic Richfield Co.)

Armco, 703 Curtis St., Middletown, Ohio 45043

Asarco, 120 Broadway, New York, N.Y. 10271

Bethlehem Steel Corp., 701 East Third St., Bethlehem, Pa. 18016

Carpenter Technology Corp., 150 West Bern St., Reading, Pa. 19603

Cerro Metal Products, P.O. Box 388, Bellefonte, Pa. 16823 (division of Marmon Group)

Chromalloy American Corp., 120 South Central Ave., St. Louis, Mo. 63105

Climax Molybdenum Co., 1 Greenwich Plaza, Greenwich, Conn. 06830 (division of Amax)

Colt Industries, P.O. Box 226, Midland, Pa. 15059

Copperweld Corp., 2 Oliver Plaza, Pittsburgh, Pa. 15222

Cyclops Corp., 650 Washington Rd., Pittsburgh, Pa. 15228

Duval Corp., P.O. Box 2967, Houston, Tex. 77001 (subsidiary of Pennzoil Co.)

Engelhard Corp., 1221 Ave. of the Americas, New York, N.Y. 10020

Fansteel, 1 Tantalum Pl., North Chicago, Ill. 60064

Foote Mineral Co., Rte. 100, Exton, Pa. 19341 (owned 90.8% by Newmont Mining Corp.)

Freeport Minerals Co., 200 Park Ave., New York, N.Y. 10166 (subsidiary of Freeport-McMoRan)

Gulf Resources & Chemical Corp., 1100 Milam Bldg., Houston, Tex. 77002

Handy & Harman, 850 Third Ave., New York, N.Y. 10022

Howmet Aluminum Corp., 475 Steamboat Rd., Greenwich, Conn. 06830 (affiliate of Pêchiney-Ugine-Kuhlmann Corp. of France)

Inland Steel Co., 30 West Monroe St., Chicago, Ill 60603

Interlake, 2015 Spring Rd., Oak Brook, Ill. 60521

International Nickel Co., 1 New York Plaza, New York, N.Y. 10004

Johnson Matthey, 4 Malin Rd., Malvern, Pa. 19355 (owned by Johnson Matthew Investments)

Jones & Laughlin Steel Corp., Robinson Plaza 3, Rte. 60, Robinson Township, Pittsburgh, Pa. 15205 (subsidiary of LTV Corp.)

Kaiser Aluminum & Chemical Corp., 300 Lakeside Dr., Oakland, Calif. 94643

Kaiser Steel Corp., 300 Lakeside Dr., Oakland, Calif. 94643

Kawecki Berylco Industries, P.O. Box 1462, Reading, Pa. 19603 (subsidiary of Cabot Corp.)

Kennametal, P.O. Box 30700, Raleigh, N.C. 27622

Kennecott Minerals Co., P.O. Box 11248, Salt Lake City, Utah 84107 [subsidiary of Standard Oil Co. (Ohio)]

Martin Marietta Aluminum, 6801 Rockledge Dr., Bethesda, Md. 20817 (subsidiary of Martin Marietta Corp.)

Molycorp, 461 South Boylston St., Los Angeles, Calif. 90017 (subsidiary of Union Oil Co. of California)

National Steel Corp., 2800 Grant Bldg., Pittsburgh, Pa. 15219

Phelps Dodge Refining Corp., 300 Park Ave., New York, N.Y. 10022 (subsidiary of Phelps Dodge Corp.)

Republic Steel Corp., P.O. Box 6778, Cleveland, Ohio 44101

Revere Copper & Brass, 605 Third Ave., New York, N.Y 10158 (owned 33% by Asarco)

Reynolds Metals Co., P.O. Box 27003, Richmond, Va. 23261

St. Joe Minerals Corp., 250 Park Ave., New York, N.Y. 10017 (subsidiary of Fluor Corp.)

Teledyne Wah Chang Albany, P.O. Box 460, Albany, Ore. 97321 (subsidiary of Teledyne)

Titanium Metals Corp. Of America, P.O. Box 2824, Pittsburgh, Pa. 15230 (jointly owned by Allegheny International and NL Industries)

U.S. Steel Corp., 600 Grant St., Pittsburgh, Pa. 15230

Food

American Maize-Products Co., 22 Gate House Rd., Stamford, Conn. 06902

Amstar Corp., 1251 Ave. of the Americas, New York, N.Y. 10020

Anderson Clayton Foods, 7839 Churchill Way, Dallas, Tex. 75251 (division of Anderson Clayton & Co.)

Archer Daniels Midland Co., P.O. Box 1470, Decatur, Ill. 62525

Armour & Co., Greyhound Tower, Phoenix, Ariz. 85077 (subsidiary of Greyhound Corp.)

Beatrice Foods Co., 2 North La Salle St., Chicago, Ill. 60602

Borden, 180 East Broad St., Columbus, Ohio 43215

Campbell Soup Co., Campbell Pl., Camden, N.J. 08101

Carnation Co., 5045 Wilshire Blvd., Los Angeles, Calif. 90036

Central Soya Co., 1300 Ft. Wayne National Bank Bldg., Ft. Wayne, Ind. 46802

Consolidated Foods Corp., 135 South La Salle St., Chicago, Ill. 60603

CPC International, International Plaza, Englewood Cliffs,N.J. 07632

Del Monte Corp., P.O. Box 3575, San Francisco, Calif. 94119 (subsidiary of R. J. Reynolds Industries)

Esmark, 55 East Monroe St., Chicago, Ill. 60603

General Foods Corp., 250 North St., White Plains, N.Y. 10625

General Host Corp., 22 Gate House Rd., Stamford, Conn. 06902

General Mills, P.O. Box 1113, Minneapolis, Minn. 55440

Gerber Products Co., Fremont, Mich. 49412

H. J. Heinz Co., 1062 Progress Rd., Pittsburgh, Pa. 15212

Hershey Foods Corp., 19 East Chocolate Ave., Hershey, Pa. 17033

Geo. A. Hormel & Co., Austin, Minn. 55912

Kellogg Co., 235 Porter St., Battle Creek, Mich. 49016

Kraft, Kraft Ct., Glenview, Ill. 60025 (subsidiary of Dart & Kraft)

Libby, McNeill & Libby, 200 South Michigan Ave., Chicago, Ill. 60604

Thomas J. Lipton, 800 Sylvan Ave., Englewood Cliffs, N.J. 07632

McCormick & Co., 11350 McCormick Rd., Hunt Valley, Md. 21031

Nabisco Brands, 625 Madison Ave., New York, N.Y. 10022

Norton Simon, 277 Park Ave., New York, N.Y. 10017

Pepperidge Farm, P.O. Box 5500, Norwalk, Conn. 06856 (subsidiary of Campbell Soup Co.)

Pet, 400 South Fourth St., St. Louis, Mo. 63166 (subsidiary of IC Industries)

Pillsbury Co., 608 Second Ave. South, Minneapolis, Minn. 55402

Quaker Oats Co., P.O. Box 3514, Chicago, Ill. 60654

Ralston Purina Co., 835 South Eighth St., St. Louis, Mo. 63188

A. E. Staley Mfg. Co., P.O. Box 151, Decatur, Ill. 62525

Stokely-Van Camp, 941 North Meridian St., Indianapolis, Ind. 46206

Swift & Co., 115 West Jackson Blvd., Chicago, Ill. 60604 (subsidiary of Esmark)

Universal Foods Corp., 433 East Michigan St., Milwaukee, Wis. 53202

Wm. Wrigley Jr. Co., 410 North Michigan Ave., Chicago, Ill. 60611

Other manufacturers

Abcor, 850 Main St., Wilmington, Mass. 01887 (subsidiary of Koch Engineering Co.)

Aerojet-General Corp., 10300 North Torrey Pines Rd., La Jolla, Calif. 92037 (subsidiary of General Tire & Rubber Co.)

Allis-Chalmers Corp., P.O. Box 512, Milwaukee, Wis. 53201

Alza Corp., 950 Page Mill Rd., Palo Alto, Calif. 94304

AM Bruning, 1800 Bruning Dr. West, Itasca, Ill. 60143 (division of AM International)

American Air Filter Co., P.O. Box 35530, Louisville, Ky. 40232

American Brands, 245 Park Ave., New York, N.Y. 10167

American Can Co., American La., Greenwich, Conn. 06830

American Hospital Supply Corp., 1740 Ridge Ave., Evanston, Ill. 60204

American Motors Corp., 14250 Plymouth Rd., Detroit, Mich. 48232

American Optical Corp., 14 Mechanic St., Southbridge, Mass. 01550 (subsidiary of Warner-Lambert Co.)

American Standard, 40 West 40th St., New York, N.Y. 10018

American Telephone & Telegraph Co., 195 Broadway, New York, N.Y. 10007

AM International, 1900 Ave. of the Stars, Los Angeles, Calif. 90067

AMP, P.O. Box 3608, Harrisburg, Pa. 17105

Ampex Corp., 401 Broadway, Redwood City, Calif. 94063 (part of Signal Companies)

Anchor Hocking Corp., 70 Glass Ave., Lancaster, Ohio 43130

Anheuser-Busch, 721 Pestalozzi St., St. Louis, Mo. 63118

Armstrong World Industries, Liberty and Charlotte St., Lancaster, Pa. 17604

Atlantic Research Corp., 5390 Cherokee Ave., Alexandria, Va. 22314

Avco Corp., 1275 King St., Greenwich, Conn. 06830

Babcock & Wilcox Co., P.O. Box 1126, Wall St. Station, New York, N.Y. 10268 (unit of J. Ray McDermott Co.)

Badger Co., 1 Broadway, Cambridge, Mass. 02142 (division of Raytheon Co.)

Baird Corp., 125 Middlesex Tpke., Bedford, Mass. 01730

Bausch & Lomb, 1 Lincoln First Sq., Rochester, N.Y. 14601

Beckman Instruments, 2500 Harbor Blvd., Fullerton, Calif. 92634 (subsidiary of SmithKline Beckman Corp.)

Becton Dickinson & Co., Mack Center Dr., Paramus, N.J. 07652

Becton Dickinson Immunodiagnostics, Mountain View Ave., Orangeburg, N.Y. 10962 (division of Becton Dickinson & Co.)

Bell & Howell Co., 7100 McCormick Blvd., Chicago, Ill. 60645

Bendix Corp., Bendix Ctr., Southfield, Mich. 48037

Bio-Dynamics, 9115 Hague Rd., Indianapolis, Ind. 46250

Blaw-Knox Equipment, Blaw St., Blawnox, Pa. 15238 (division of White Consolidated Industries)

Borg-Warner Corp., 200 South Michigan Ave., Chicago, Ill. 60604

Bostik division, 20846 South Normandie Ave., Torrance, Calif. 90502 (unit of Emhart)

Budd Co., 3155 West Big Beaver Rd., Troy, Mich. 48084

Burlington Industries, P.O. Box 21207, Greensboro, N.C. 27420

Burroughs Corp., Burroughs Pl., Detroit, Mich. 48232

Carborundum Co., P.O. Box 337, Nigara Falls, N.Y. 14302 (division of Kennecott Corp.)

Cargill, P.O. Drawer 5630, Minneapolis, Minn. 55440

Caterpillar Tractor Co., 100 N.E. Adams St., Peoria, Ill. 61629

Celotex Corp., P.O. Box 22602, Tampa, Fla. 33622 (division of Jim Walter Corp.)

Chemical Products Corp., P.O. Box 449, Cartersville, Ga. 30120

Chrysler Corp., P.O. Box 1919, Detroit, Mich. 48288

C&I Girdler, P.O. Box 32940, Louisville, Ky. 40232 (division of Bechtel Corp.)

Combustion Engineering, 900 Long Ridge Rd., Stamford, Conn. 06902

Continental Can Co. U.S.A., 51 Harbor Plaza, Stamford, Conn. 06904 (member of Continental Group)

Coors Porcelain Co. 600 Ninth St., Golden, Colo. 80401 (division of Adolph Coors Co.)

Corning Glass Works, 80 Houghton Park, Corning, N.Y. 14830

Crown Cork & Seal Co., 9300 Ashton Rd., Philadelphia, Pa. 19136

Curtiss-Wright Corp., 1 Passaic St., Wood-Ridge, N.J. 07075

Dan River International Corp., 111 West 40th St., New York, N.Y. 10018

Dayco Corp., 333 West First St., Dayton, Ohio 45402

Deere & Co., John Deere Rd., Moline, Ill. 61265

Dorr-Oliver, 79 Havemeyer La., Stamford, Conn. 06904 (subsidiary of Kennecott Corp.)

Dresser Industries, 1505 Elm St., Dallas, Tex. 75201

Eastman Kodak Co., 343 State St., Rochester, N.Y. 14650

El Paso Co., P.O. Box 2185, Houston, Tex. 77001

Evans Products Co., P.O. Box 3295, Portland, Ore. 97208

Fairchild Camera & Instrument Corp., 464 Ellis St., Mountain View, Calif. 94042

Fasson Industrial Division, 252 Chester St., Painesville, Ohio 44077 (division of Avery International)

Flintkote Co., 777 Long Ridge Rd., Stamford, Conn. 06902 (part of Genstar Ltd.)

Fluor Corp., 3333 Michelson Dr., Irvine, Calif. 92730

Ford, Bacon & Davis, 2 Broadway, New York, N.Y. 10004

Ford Motor Co., American Rd., Dearborn, Mich. 48127

Foremost-McKesson, 1 Post St., San Francisco, Calif. 94104

Foster Wheeler Energy Corp., 110 South Orange Ave., Livingston,N.J. 07039

Foxboro Co., 86 Neponset Ave., Foxboro, Mass. 02035

Franklin GNO Corp., P.O. Box 3206, West Palm Beach, Fla. 33402

H. B. Fuller Co., 2402 Kasota Ave., St. Paul, Minn. 55108

GATX Corp., 120 South Riverside Plaza, Chicago, Ill. 60606

General Dynamics Corp., Pierre Laclede Ctr., St. Louis, Mo. 63105

General Electric Co., 3135 Easton Ave., Fairfield, Conn. 06431

General Motors Corp., 3044 West Grand Blvd., Detroit, Mich. 48202

General Resource Corp., 203 South Third St., Hopkins, Minn. 55343

General Telephone & Electronics Corp., 1 Stamford Forum, Stamford, Conn. 06904

Grain Processing Corp., P.O. Box 349, Muscatine, Iowa 52761

Greyhound Corp., 111 West Clarendon Ave., Phoenix, Ariz. 85077

Grumman Corp., 1111 Stewart Ave., Bethpage, N.Y. 11714

Gulf & Western Industries, P.O. Box 4239, Grand Central Station, New York, N.Y. 10164

G&W Electric Specialty Co., 3500 West 127th St., Blue Island, Ill. 60406

Honeywell, Honeywell Plaza at 27th St., Minneapolis, Minn. 55408

Inco Electro-Energy, 5 Penn Ctr. Plaza, Philadelphia, Pa. 19103

Indian Head, 1211 Ave. of the Americas, New York, N.Y. 10036

Instrumentation Laboratory, 113 Hartwell Ave., Lexington, Mass. 02173

International Business Machines Corp., Old Orchard Rd., Armonk, N.Y. 10504

International Harvester Co., 401 North Michigan Ave., Chicago, Ill. 60611

International Playtex, 888 Seventh Ave., New York, N.Y. 10019 (division of Esmark)

InterNorth, 2223 Dodge St., Omaha, Neb. 68102

Interpace Corp., 260 Cherry Hill Rd., Parsippany, N.J. 07054

Ionics, 65 Grove St., Watertown, Mass. 02172

Itek Corp., 10 Maguire Rd., Lexington, Mass. 02173

Johnson & Johnson, 501 George St., New Brunswick, N.J. 08903

Johnson Wax, 1521 Howe St., Racine, Wis. 53403

Jones-Blair Co., P.O. Box 35286, Dallas, Tex. 75235

Leeds & Northrup Co., Sumneytown Pike, North Wales, Pa. 19454

Libbey-Owens-Ford Co., 811 Madison Ave., Toledo, Ohio 43695

Liggett Group, 4100 Roxboro Rd., Durham, N.C. 27702

Litton Industries, 360 North Crescent Dr., Beverly Hills, Calif. 90210

Lockheed Corp., 2555 North Hollywood Way, Burbank, Calif. 91520

Loctite Corp., 999 North Mountain Rd., Newington, Conn. 06111

Lorillard, 666 Fifth Ave., New York, N.Y. 10103 (division of Loews Corp.)

LTV Corp., P.O. Box 225003, Dallas, Tex. 75265

Lummus Co., 1515 Broad St., Bloomfield, N.J. 07003 (subsidiary of Combustion Engineering)

3M Co., 3M Ctr., St. Paul, Minn. 55144

Mallory Components Group, 3029 East Washington St., Indianapolis, Ind., 46206 (part of Emhart Corp.)

Manville Corp., Ken-Caryl Ranch, Denver, Colo. 80217

Marcor, 535 West Chicago Ave., Chicago, Ill. 60610

Martin Marietta Corp., 6801 Rockledge Dr., Bethesda, Md. 20034

Masonite Corp., P.O. Box 1048, Laurel, Miss. 39440

McDonnell Douglas Corp., P.O. Box 516, St. Louis, Mo. 63166

McGaw Laboratories, P.O. Box 11887, Santa Ana, Calif. 92711 (division of American Hospital Supply Corp.)

McGraw-Edison Co., 1701 Golf Rd., Rolling Meadows, Ill. 60008

Meloy Laboratories, 6715 Electronics Dr., Springfield, Va. 22151 (subsidiary of Revlon)

Millipore Corp., 80 Ashby Rd., Bedford, Mass. 01730

Mine Safety Appliances Co., 608 Penn Center Blvd., Pittsburgh, Pa. 15235

Philip Morris, 100 Park Ave., New York, N.Y. 10017

Motorola, 1303 East Algonquin Rd., Schaumburg, Ill. 60196

MRC Corp., 11212 McCormick Rd., Hunt Valley, Md. 21031

Nashua Corp., 44 Franklin St., Nashua, N.H. 03061

National Can Corp., 5959 South Cicero Ave., Chicago, Ill. 60638

National Gypsum Co., 4100 First International Bldg., Dallas, Tex. 75270

NCR Corp., 1700 South Patterson Blvd., Dayton, Ohio 45479

Nicolet, Ford & Washington St., Norristown, Pa. 19401

NL Industries, 1230 Ave. of the Americas, New York, N.Y. 10020

Northern Gas Products Co., 2223 Dodge St., Omaha, Neb. 68102 (part of InterNorth)

Norton Co., 50 New Bond St., Worcester, Mass. 01606

Owens-Corning Fiberglas Corp., Fiberglas Tower, Toledo, Ohio 43659

Owens-Illinois, P.O. Box 1035, Toledo, Ohio 43666

Para-Chem, Ontario and Rorer St., Philadelphia, Pa. 19114

Parkson Corp., 5601 Northeast 14th Ave., Ft. Lauderdale, Fla. 33334 (subsidiary of A. Johnson Co.)

Ralph M. Parsons Co., 100 West Walnut St., Pasadena, Calif. 91124

PCR, P.O. Box 1466, Gainesville, Fla. 32601 (part of organic chemicals division of SCM Corp.)

Perkin-Elmer Corp., Main Ave., Norwalk, Conn. 06856

Pierce & Stevens Chemical Corp., 724 Ohio St., Buffalo, N.Y. 14203 (division of Pratt & Lambert)

Polaroid Corp., 549 Technology Sq., Cambridge, Mass. 02139

Polymer Applications, 3443 River Rd., Tonawanda, N.Y. 14150

Polymer Industries, P.O. Box 2184, Greenville, S.C. 29602 (subsidiary of Philip Morris)

Pratt & Whitney Aircraft Group, 400 Main St., East Hartford, Conn. 06108 (division of United Technologies Corp.)

Pullman Power Products, P.O. Box 3308, Williamsport, Pa. 17701 (division of Wheelabrator-Frye)

Radiation Management Corp., 3508 Market St., Philadelphia, Pa. 19104

Raychem Corp., 300 Constitution Dr., Menlo Park, Calif. 94025

RCA Corp., 30 Rockefeller Plaza, New York, N.Y. 10020

Research-Cottrell, P.O. Box 1500, Somerville, N.J. 08876

R.J. Reynolds Industries, 401 North Main St., Winston-Salem, N.C. 27102

H. H. Robertson Co., 400 Holiday Dr., Pittsburgh, Pa. 15220

Rockwell International Corp., 600 Grant St., Pittsburgh, Pa. 15219

Sargent-Welch Scientific Co., 7300 North Linder Ave., Skokie, Ill. 60077

Jos. Schlitz Brewing Co., 235 West Galena St., Milwaukee, Wis. 53201 (subsidiary of Stroh Brewery Co.)

Scientific Design Co., 2 Park Ave., New York, N.Y. 10016 (subsidiary of Halcon International)

SCM Corp., 299 Park Ave., New York, N.Y. 10017

Sears, Roebuck & Co., Sears Tower, Chicago, Ill. 60684

Signal Cos., P.O. Box 2829, La Jolla, Calif. 92037

Singer Co., 8 Stamford Forum, Stamford, Conn. 06904

SmithKline Beckman Corp., 1500 Spring Garden St., Philadelphia, Pa. 19101

Spectra-Physics, 3333 North First St., San Jose, Calif. 95134

Sprague Electric Co., 149 Marshall St., North Adams, Mass. 01247

J.P. Stevens & Co., 1185 Ave. of the Americas, New York, N.Y. 10036

Stone & Webster Engineering Corp., P.O. Box 2325, Boston, Mass. 02107 (subsidiary of Stone & Webster)

Swedlow, 12122 Western Ave., Garden Grove, Calif. 92645

Teepak, 2 North Riverside Plaza, Chicago, Ill. 60606 (member of Continental Group)

Tektronix, P.O. Box 1700, Beaverton, Ore. 97075

Texas Instruments, P.O. Box 225012, Dallas, Tex. 75222

Thiokol Corp., Newtown-Yardley Rd., Newtown, Pa. 18940

U.S. Gypsum Co., 101 South Wacker Dr., Chicago, Ill. 60606

United Technologies Corp., 1 Financial Plaza, Hartford, Conn. 06101

UOP, 10 UOP Plaza, Algonquin Rd., Des Plaines, Ill. 60016 (subsidiary of Signal Cos.)

Varian Associates, 611 Hansen Way, Palo Alto, Calif. 94303

Jim Walter Corp., 1500 North Dale Mabry Hwy., Tampa, Fla. 33607

Western Electric Co., 222 Broadway, New York, N.Y. 10038 (division of American Telephone & Telegraph Co.)

Westinghouse Electric Corp., 3 Gateway Ctr., Pittsburgh, Pa. 15222

Xerox Corp., High Ridge Park, Stamford, Conn. 06904

Zenith Radio Corp., 1000 North Milwaukee Ave., Glenview, Ill. 60025

Research

Argonne National Laboratory, 9700 South Cass Ave., Argonne, Ill. 60439

Battelle Columbus Laboratories, 505 King Ave., Columbus, Ohio 43201

Battelle Pacific Northwest Laboratories, P.O. Box 999, Richland, Wash. 99352

Bell Laboratories, 600 Mountain Ave., Murray Hill, N.J. 07974 (division of American Telephone & Telegraph Co.)

Brookhaven National Laboratory, Upton, Long Island, N.Y. 11973

Chemical Abstracts Service, P.O. Box 3012, Columbus, Ohio 43210

Commercial Testing & Engineering Co., 228 North La Salle St., Chicago, Ill. 60601 (division of GEO International Corp.)

Denver Research Institute, University of Denver, University Park, Denver, Colo. 80208

Exxon Research & Engineering Co., P.O. Box 221, Florham Park, N.J. 07932 (division of Exxon Corp.)

Franklin Institute, 20th & Race St., Philadelphia, Pa. 19103

Gillette Research Institute, 1413 Research Blvd., Rockville, Md. 20850

IIT Research Institute, 10 West 35th St., Chicago, Ill. 60616

Institute of Gas Technology, 3424 South State St., Chicago, Ill. 60616

Institute of Paper Chemistry, P.O. Box 1039, Appleton, Wis. 54912

Lawrence Berkeley Laboratory, University of California, 1 Cyclotron Rd., Berkeley, Calif. 94720

Lawrence Livermore National Laboratory, University of California, Berkeley, Calif. 94720

Arthur D. Little Inc., Acorn Park, Cambridge, Mass. 02140

Los Alamos National Laboratory, P.O. Box 1663, Los Alamos, N.M. 87545

Materials Research Laboratory, University of Illinois, Urbana, Ill. 61801

Mellon Institute, Carnegie-Mellon University, 4400 Fifth Ave., Pittsburgh, Pa. 15213

Midwest Research Institute, 425 Volker Blvd., Kansas City, Mo. 64110

Oak Ridge National Laboratory, P.O. Box X, Oak Ridge, Tenn. 37830

Rand Corp., 1700 Main St., Santa Monica, Calif. 90406

Research Triangle Institute, P.O. Box 12194, Research Triangle Park, N.C. 27709

Sandia National Laboratories, P.O. Box 5800, Albuquerque, N.M. 87115

Foster D. Snell Inc., 66 Hanover Rd., Florham Park, N.J. 07932 (division of Booz, Allen & Hamilton)

Southern Research Institute, 2000 Ninth Ave. South, Birmingham, Ala. 35255

Southwest Research Institute, 6220 Culebra Rd., San Antonio, Tex. 78284

SRI International, 333 Ravenswood Ave., Menlo Park, Calif. 94025

Sterling-Winthrop Research Institute, Columbia Tpke., Rensselaer, N.Y. 12144 (division of Sterling Drug)

Syracuse Research Corp., Merrill La., Syracuse, N.Y. 13210

Underwriters Laboratories, 333 Pfingsten Rd., Northbrook, Ill. 60062

United States Testing Co., 1941 Park Ave., Hoboken, N.J. 07030 □

Chemical & Engineering NEWS

Congressional voting record on issues of interest to chemists Page 18

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Mineral inorganics

Sulfur joins the rest in market slide

A Key Chemicals Review Page 9

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Chemical & Engineering NEWS

Cover: Vats of solid sulfur at Freeport-McMoran's facilities at Port Sulphur, Tex.

2 Letters
3 Editor's Page

Concentrates
7 Business
15 Government
24 Science/Technology

The Departments
29 ACS News
30 Awards
40 Newscripts

News of the Week

- ***Nobel prize in chemistry*** *goes to Aaron Klug of U.K.'s MRC Laboratory of Molecular Biology, and in physics to Kenneth G. Wilson of Cornell.* ***Page 4***
- ***Drug approval process up for revamping;*** *FDA proposes a series of revisions that could reduce processing time six months by requiring less review time.* ***Page 5***
- ***Third-quarter earnings*** *at most U.S. chemical companies continue a downward trend; Mexican peso devaluation adds new problems for the industry.* ***Page 5***
- ***Ban on toxaphene,*** *issued by the Environmental Protection Agency, prohibits most uses of this pesticide that replaced DDT and wreaked ecological havoc.* ***Page 6***
- ***New method for transferring genes*** *makes use of certain DNA segments called transposone and opens up the potential for precise experimental control.* ***Page 6***

Business

- ***Major mineral inorganics****—lime, sulfur, potash, and phosphorus—all are feeling the effects of the current recession, with sulfur the most recent inorganic to join the slump.* ***Page 9***
- ***Loctite's Robert H. Krieble*** *has helped bring his firm up to sales of some $200 million by building on a chemical way to fasten, or lock, nuts and bolts.* ***Page 14***

Government

- ***White House panel recommends changes*** *in food safety laws, including greater use of scientific review and revamping of the Delaney clause.* ***Page 16***
- ***EPA's research and development plans*** *are under fire from their own science advisory board.* ***Page 17***
- ***Voting records of Congressmen*** *on six different bills of concern to chemists are summarized.* ***Page 18***

Science

- ***Highly strained tricyclic molecule*** *is synthesized and shows unusual stability, apparently because possible decomposition pathways are not favored.* ***Page 25***
- ***Ellagic acid is found to inactivate*** *the potent carcinogen benzo[a]pyrene in vitro by forming innocuous adducts.* ***Page 26***
- ***Claims of new water-splitting advances*** *should not be interpreted as commercial breakthroughs, researchers say.* ***Page 27***
- ***Substances that attract coyotes specifically*** *are being sought to control the predators more effectively.* ***Page 27***

Technology

- ***Kodak's new high-speed film,*** *spawned by emulsion technology, offers excellent grain and sharpness.* ***Page 28***

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Sulfur joins mineral inorganics' recession

Long thought to be strong indefinitely in the 1980s, sulfur has yielded to the same market woes afflicting lime, potash, and phosphorus

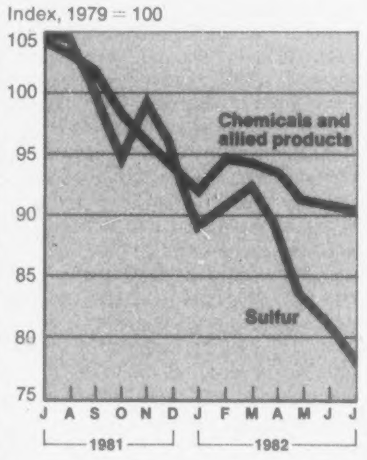
Bruce F. Greek
C&EN, Houston

Organic chemicals seem to be getting all the attention in this recession, which has slashed production, prices, and new investment. But inorganics such as the four treated here—lime, sulfur, potash, and phosphorus—also have gone into the soup. Recession took longer to reach some of these big inorganics, especially sulfur, but the results are now the same.

Production in all these inorganics will be down substantially from 1981. Declines expected in 1982 range from 13 to 18% of 1981 production. Total value of sales and captive use for these inorganics will drop over an even broader range, from less than 1% for phosphorus to more than 35% for lime.

The recovery from such depths will not come quickly or easily, industry analysts fear. Although improvement in both demand and value of these inorganics is expected in 1983, recovery to 1981 production levels might be too much to hope for. In fact, the more pessimistic observers pick 1985 for full recovery.

Sulfur output has fallen harder than all chemicals



Source: Department of Interior, Federal Reserve Board

All told, about 29 million tons of these four inorganics will be produced in 1982, with a value of about $2.75 billion. Lime and sulfur account for nearly 90% of combined production volume and two thirds of the value.

So when lime and sulfur slump, the group as a whole has to tumble.

Key Chemicals

Combined output for these two is expected to decline more than 5.5 million tons in 1982, accounting for most of the total volume decline from 1981 production of about 36 million tons. This slump and resulting pressure on prices will chop about $500 million from total commercial value.

The slump in lime began before that in sulfur. Lime's problem comes from heavy dependence on the steel industry as an end use. Since the long-term outlook in steel is very tarnished, prospects for recovery in lime are best called long-term, too, even though lime has better potential growth in demand from newer uses than does sulfur. Even if the market for lime in steelmaking never again reaches 1970s' levels in the U.S., total demand for lime could exceed former highs because of pollution-control uses. These outlets are growing as much as 10% a year and could propel lime to new records by the mid-1980s.

Sulfur's dependence on a single end use in phosphate fertilizer is more extreme and finally has done it in. Fertilizer takes more than 60% of sulfur, almost entirely through sulfuric acid. (Direct-application sulfur and sulfur-containing pesticides account for some additional demand.) So sulfur can't do well again until fertilizer use turns up.

Exports of sulfur, here being dumped in ship's hold, are down sharply

The longer-term outlook for U.S.-produced sulfur is heavily dependent on foreign trade in fertilizers. Problems have arisen this year as both U.S. and foreign fertilizer producers and consumers reduced inventories of phosphate fertilizers. Inventories of sulfur, too, were cut, mainly because of the high cost of money. Rebuilding inventories could take some time in both fertilizer and sulfur, perhaps two years or more. For producers, one result will be only a small rise in sulfur demand to meet export needs.

In other parts of the world, prospects for increased demand for sulfur or sulfur products from the U.S. have dimmed because of competition. An important factor is increased phosphate fertilizer output in North Africa made from by-product sulfur from the Middle East. This fertilizer is being pressed into world markets at low prices to gain hard currencies. Other new fertilizer sources such as Mexico also might take this route to get into developing markets.

Since sulfur is the most dependent of these four inorganics on exports, it has the most confusing outlook over the next few years. But each of these quite mature inorganics will remain under strong downward pressure on demand.

For immediate market details on each of these inorganics, see the following pages.

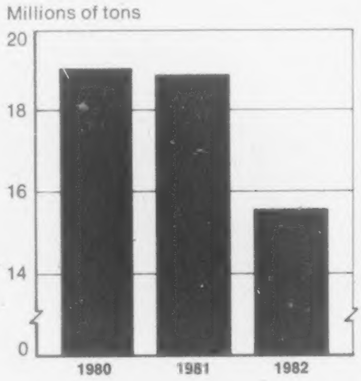
Key Chemicals

Lime

CaO

- ***Demand slack***
- ***Capacity excessive***
- ***Prices weak***

PRODUCTION



Note: No capacity estimates are available.

HOW MADE

Calcining limestone (mainly $CaCO_3$) to make quicklime (CaO); then adding water to make hydrated lime, $Ca(OH)_2$

MAJOR END USES

Metallurgy (mainly steel flux) 40%, chemical manufacture 10%, potable water treatment 10%, sewage and pollution control 10%, construction 5%, pulp and paper manufacture 5%

FOREIGN TRADE

Exports—holding at about 40,000 tons in 1982; imports—down substantially to about 425,000 tons

PRICES

$30 to $50 per ton, depending on type; discounting significant

COMMERCIAL VALUE

$500 million for production, 1982

U.S. lime producers are reeling under the impact of the recession about in line with the chemical industry as a whole, with production down about 18% from 1981. They have been coping with the same difficult problems everyone has faced in 1982—torpedoed demand in major uses, large overcapacity, rising production costs, and price weakness.

Because of similar damage from the recession and from imports in the steel industry, lime's major customer, lime has few bright spots at the moment. As expected, pollution control continues to provide some demand growth for lime and is the main hope in the future. Most other uses are either at a standstill or in decline.

Since steel operations are at historically low levels compared to capacity, lime demand could be down as much as 50% this year in this use. Because steel and other metallurgical uses generally make up more than 40% of U.S. lime consumption, it is easy to see why analysts forecast 1982 lime production at no more than 15.5 million tons, down some 3.4 million tons from 1981.

For a product as stable as lime, the production drop this year is quite a shock. Output in 1982 will be the lowest since 1963. Generally, lime volume rose through the 1960s and then plateaued through the 1970s as growth in steel tailed off.

Production has risen some in recent months, but not very much. Output for the first seven months of 1982 is estimated to be down more than 20% from a year ago. Some freshening in demand because of pinched inventories and the usual seasonal autumn pickup in sugar beet processing is expected to ease the decline for the whole year.

No industrywide capacity estimates are available for lime. However, industry sources say that plant operating rates are down, even though some plants have been closed. The overall sag is called the worst since the 1930s' depression.

Lime's slump began before this year. In fact, the recent production high point was 21.0 million tons in 1979. The U.S. Bureau of Mines puts the total number of plants in the U.S. operating at least in part in 1981 at 151, down three from 1980. The plant list will drop at least this much again in 1982.

However, plants making lime, basically kilns and auxillary equipment, can be left shut down for relatively long periods without major damage. Plants also can be started up in a relatively short time at low cost compared to most other chemical plants. It is these shut-down lime plants that make estimates so hazy for operable capacity and actual operating rates.

Lime operations, especially in captive plants, are influenced heavily by changes in use patterns. For example, many uses take both lime and limestone, though not in specific areas. In steel making, lime is used in basic oxygen and electric furnace plants, whereas limestone is used as the flux in open hearth furnace steel plants. Hence, the shift to basic oxygen and electric furnaces caused lime demand to grow rapidly until the recent slowdown.

The major lime use that continues to grow is pollution control. Most important for the longer term is stack gas scrubbing to remove sulfur dioxide. For 1982, analysts estimate that more than 1 million tons of lime will be used for pollution control, mainly for dry scrubbing of gases. Many additional scrubbers are being built or planned, and growth in this use could continue as much as 10% per year in 1983 after a similar gain in 1982. The future for this use of lime (and for use of limestone in wet scrubbers as well) depends heavily on any future government decisions on the seriousness of the acid rain problem arising from utility stacks.

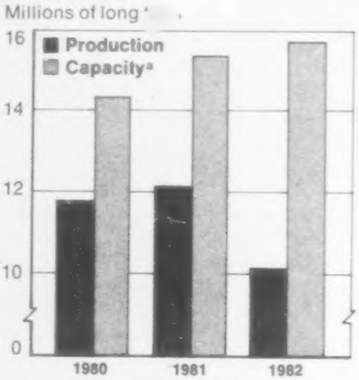
Many other uses of lime are holding their own in 1982 or are expanding a little. Unfortunately, these uses are small compared to steel and will not offset the decline there. For example, use of lime in construction for soil stabilization and other purposes might be up 2% in 1982 in spite of a drop in total construction. Wastewater treating, which includes municipal sewage treatment, also is expected to post a small gain in 1982.

Most of the other markets for lime, such as pulp and paper making or glass making, will have small declines in use this year. But their impact on total lime demand will be minimal, much like the net impact of growing uses. On balance then, lime producers will have to wait out the recession in steel before getting back on a growth curve.

Sulfur

- ***Demand down***
- ***Capacity peaking***
- ***Prices down***

PRODUCTION/CAPACITY



a All-sources as of first quarter; excludes standby capacity of about 5 million long tons at recovery plants and smelters.

HOW MADE

Melted from underground deposits, recovered from sulfur compounds processed in refineries, natural gas processing plants, and smelters

MAJOR DERIVATIVES (U.S.)

Sulfuric acid 90%, chemicals 5%

MAJOR END USES (U.S.)

Fertilizer 60%, chemicals 20%

FOREIGN TRADE

Exports—declining in 1982 to about 900,000 long tons; imports—down to about 2.25 million long tons

PRICES

$135 per long ton f.o.b. Tampa, Fla.

COMMERCIAL VALUE

$1.2 billion for production, 1982

One of the most recession-resistant products in the entire U.S. chemical industry a year ago has joined the pack. Sulfur, most of which is converted to sulfuric acid, is one of the true work-horse materials of the chemical industry. But this year it has gone lame. This important inorganic starting chemical has suffered badly from declining demand topped off by a round of lower posted prices as the fourth quarter opened.

Next year, especially in the second half, the grass may be greener and sulfur demand improve. However, full recovery to 1981 levels won't happen that soon.

Fertilizer, which uses sulfuric acid to make phosphoric acid, accounts for 60% of all sulfur use. In 1982, fertilizer demand in both the U.S. and export markets has declined more than expected by most industry observers. A leading factor has been the high cost of money, which has aggravated across-the-board cuts in inventories of finished fertilizers. Upstream phosphoric acid manufacture dropped drastically, followed quickly by a slide in sulfur demand.

Nonfertilizer uses of sulfuric acid such as making chemicals and steel also have declined, but less drastically because of the recession. These drops in acid demand further reduced need for sulfur.

Output of sulfur for 1982 will be down especially sharply in the Frasch mining category. Current estimates are that Frasch sulfur production will be off by about 1.7 million long tons (more than 25%) this year as Frasch producers cope with reduced demand and a return of their inventories to acceptable levels.

Other sources of sulfur or its equivalent will change less drastically in 1982. Recovered sulfur from petroleum and natural gas may be up very slightly as crude oil processed in the U.S. continues its sour (sulfur-heavy) trend. Smelter gas sulfur equivalents will be down somewhat, probably less than 10%, because of the decline in demand for nonferrous metals, mostly copper. Total production of sulfur is expected to be about 10.1 million tons.

Capacity to produce sulfur may decline slightly during 1982 after rising for a number of years to reach 1[illegible] million long tons per year in the first quarter. As in the past, recovered sulfur capacity will continue to rise because of the need to control sulfur emissions and to prevent sulfur or a derivative from poisoning catalysts. This year the expansion in recovery capacity could be smaller than in 1981 because fewer large hydrosulfurizing units will be added in refineries and because gas available for processing will do better than hold even.

One shutdown of Frasch capacity occurred in 1981. Texasgulf, a subsidiary of France's Elf Aquitaine, closed its Moss Bluff mine near Liberty, Tex., in the third quarter. This mine had capacity estimated by industry sources at about 300,000 tons per year, but it was not being run anywhere close to capacity.

Current Frasch sulfur capacity is about 7.5 million tons a year. The operating rate for these mines will be about 60% of probable capacity. Operating rates for units producing other kinds of sulfur or its equivalent are hazy because most of those operations carry 100% extra capacity as insurance to avoid interruptions in primary operations if sulfur processing units have to be shut down for mechanical reasons.

The Frasch operating rate about matches estimates of present sulfuric acid and phosphoric acid plant operating rates—a clear indication of the importance of these end uses to sulfur demand. A pickup in all these operating rates may be as much as a year in coming, according to some industry sources.

The slump in phosphoric acid production began with a large cut in inventories of phosphate fertilizers in 1981 and carried over into 1982. On top of inventory cutting, farm use of phosphate fertilizers in the last crop year, ending in June, was down about 10%. The current crop year probably will match 1982 with some additional drawdown of inventory in early 1983. Hopes for a pickup in sulfur demand in the second half of 1983 rest on rebuilding inventories and on improving exports.

The nonfertilizer uses of sulfuric acid also may not really pick up until well into 1983 if general recovery takes hold. None of these secondary volume uses seems to be up in 1982. Most of these will not get back to 1981 or earlier levels until after 1983.

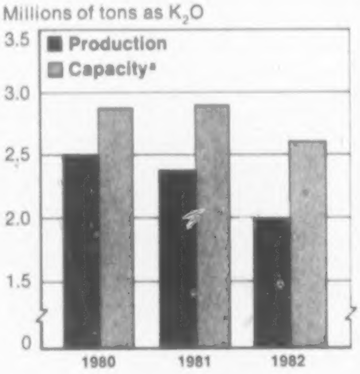
Key Chemicals

Potash

KCl, K_2SO_4, $K_2SO_4 \cdot 2MgSO_4$

- ***Demand slowing***
- ***Capacity down***
- ***Prices flat***

PRODUCTION/CAPACITY



[a] First quarter.

HOW MADE

Shaft and solution mining of potassium salts, mainly the chloride, and subsequent purification

MAJOR END USES

Fertilizer 95%

FOREIGN TRADE

Exports—declining this year to about 500,000 tons; imports—down 10% this year to about 5 million tons

PRICES

\$110 to \$130 per ton of K_2O equivalent

COMMERCIAL VALUE

\$225 million for production, 1982

Like sulfur, potash depends on a single end use, fertilizer. So when farm income in the U.S. and abroad does well, potash demand goes well. But when farm income falls, potash demand weakens as inventories are reduced to keep down interest costs. That's what is going on now.

This drop will put 1982 U.S. potash production at 2.0 million tons, the lowest point since 1954 following a decade and a half of decline. The high point for U.S. output was 3.3 million tons in 1966. Potash seemed to stabilize in the late 1970s and even enjoyed good years in the fertilizer boom at the end of the decade. But for U.S. producers, that is all now in the past.

The impact of slowing U.S. demand also falls heavily on Canadian producers. Imports of Canadian potash this year are expected to fall 10% or more, probably more than 500,000 tons measured in terms of potassium oxide (K_2O) content. U.S. production also will be down in 1982, by 400,000 tons or 16% from 1981 production of 2.4 million tons of K_2O equivalent.

Potash is the outstanding example of a major-volume U.S. chemical commodity dependent on imports for more than half of its total demand. U.S. production covers just a quarter of demand. Variables of production cost and location—in effect, transportation costs—are behind this reliance on imports. Canadian potash production is mostly in Saskatchewan, closer to the major fertilizer demand areas of the U.S. Midwest than are most U.S. mines in New Mexico and Utah.

The high level of potash imports, however, doesn't prevent exports. Exports take nearly a quarter of U.S. production now. Most of these exports move through U.S. Gulf Coast ports to Latin America, again for reasons of lower transportation cost than from Canada. Other big importers of U.S. potash are in the western Pacific.

Strong exports and potential to capture more of the U.S. market would seem to provide enough demand to use all of U.S. capacity to mine and process potash. Unfortunately, this is not the case in 1982 and hasn't been for some time. Typically, U.S. producers of potash run their operations at about 85% of nameplate capacity. Slowing demand has even caused a reduction in capacity. Last year, National Potash closed its mine near Carlsbad, N.M., with a capacity of about 275,000 tons per year. This closure cut U.S. capacity to about 2.7 million tons per year.

Even with this plant closure, the average operating rate in 1982 will decline to about 74% of nameplate capacity. Currently, operating rates are estimated at 70% of nameplate capacity in a seasonally low fourth quarter.

Producers don't expect demand for potash to increase much in 1983. Matching 1982 spring demand apparently is all most of them hope to do. And spring 1982 was a distinct disappointment. Fertilizer experts had expected spot shortages of potash because of a squeezed supply of rail cars. As it turned out, spring demand wasn't as good as forecast, and inventories in regional warehouses became swollen.

A seasonal rush to meet fertilizer demand next spring is again anticipated. But again, big regional inventories plus general slack in rail shipping probably will avert any real supply problems.

The long-term trend for potash demand in the U.S., as well as in some other countries such as Brazil, has been for a slow increase, 2 to 4% per year. Most demand growth has been attributed to increases in production of soybeans in these countries. As with other major plant nutrients, there's disagreement over near-term importance of potassium in soils. As a result, farmers are inclined to try to get by on residual potassium in soils during times, like now, when money is tight. Some farmers prefer to put their fertilizer money into nitrogen at the expense of potash with the aim of an immediate increase in production.

None of the nonfertilizer uses of potash, about 5% of the total, is showing any signs of major growth this year. Most of these uses are quite specialized. Many of the potassium chemicals are derived from potassium hydroxide, made by electrolysis of the chloride, the dominant mined form. Some of the derivatives such as potassium phosphates also go into fertilizers in small quantities for crops sensitive to chloride or sulfate ions. The other uses range from detergent builders to special soaps, specialty glasses, water and metal treatments, and many more.

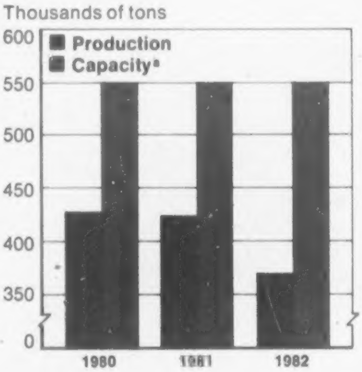
Key Chemicals

Phosphorus

P_4

- ***Demand off***
- ***Capacity flat***
- ***Price holding up***

PRODUCTION/CAPACITY



a First quarter.

HOW MADE

Reduction of phosphate rock in electric furnaces with carbon and silica as aids

MAJOR DERIVATIVES (U.S.)

Phosphoric acid and derivatives 85%, other chemicals 10%

MAJOR END USES (U.S.)

Detergents 40%, foods and beverages 15%, metal treating 10%

FOREIGN TRADE

Exports—down to about 15,000 tons in 1982; imports—negligible

PRICES

90 cents to $1.00 per lb at plants; merchant volume very small

COMMERCIAL VALUE

$700 millions for production, 1982

Phosphorus, like many inorganic chemicals, provides a good example of a mature product wide open to business cycles. This year, its production will decline more than 10% under the impact of the recession with some added loss in exports. Longer term, few prospects exist for an increase in demand other than for use in making small-volume products considered specialty chemicals.

Two of phosphorus' major uses, detergents and food, can be affected by influences other than those related directly to the economy. Environmental concerns, though no longer a heavy influence on phosphate materials in detergents, still exist and underlie some reformulation efforts, including a trend toward zeolites (C&EN, Sept. 27, page 10). In another case, shifts in consumer tastes in baked goods, soft drinks, and convenience foods change demand for phosphoric acid derivative.

These outside influences and the recessionary decline in manufacturing will cause a drop in phosphorus production in 1982 of about 12%, or 50,000 tons or so. Actual production will be about 372,000 tons, well below the recent high of 460,000 tons in 1979. The historic high occurred 10 years before at 620,000 tons.

Over the years, phosphorus plant capacity has declined, too. For now, capacity is stable at about 550,000 tons per year. Present nameplate capacity likely will hold for two years at least.

Unless something unusual happens in the fourth quarter of 1982 to accelerate phosphorus derivatives in their long pipeline from elemental phosphorus, U.S. phosphorus producers will run their electric furnaces at 67% of nameplate capacity on the average. The rate will be down significantly from 77.5% in 1981—suggesting that phosphorus producers have the same problems as do most operators in the chemical industry in covering expenses fully.

Since the industry is operating at two thirds of nameplate capacity, chances of capacity expansion are slim. Costs for furnaces, including expensive pollution control equipment, run high. And further market loss could occur if technology improves to purify wet-process phosphoric acid, making it competitive with phosphorus-derived acid in food-grade uses.

With the exception of a small uptick in 1979, phosphorus production trended down all through the 1970s. Behind the downtrend was the shift in detergents. Local phosphate bans hurt this largest use of elemental phosphorus for a long time. Current reformulations of detergents, including some of the newer brands with higher phosphate contents, again could reduce phosphorus demand.

At present, industry sources say the impact of reformulation is fogged up by the economy. The recession has hit sales of detergents along with almost everything else. Consumers apparently are being more careful in measuring the quantity needed, cutting use, or just not washing clothes as much. Even if detergent demand recovers, long-term growth at best will be in line with the slow growth of population.

Use of phosphoric acid and derivatives in foods, beverages, and dentifrices also has projections blurred by the recession. Under better economic conditions, growth rates in these uses would be a bit higher than of population, due to innovation in consumer products containing phosphoric acid derivatives. Product development can help, but product acceptance has proven uncertain in the past, making forecasters leery of expecting greatly improved growth rates.

The third largest use of these derivatives has been in metal treating, mainly for surface preparation of steel for automobiles. With auto production in the U.S. running about half the levels of a few years ago, this use of phosphorus has tumbled. Competition also comes and goes for phosphatizing in the auto industry as different finishes are developed and different means are proposed to slow the corroding effects of salts used to melt snow on streets. The likelihood of a slow general recovery and the shift toward smaller cars means that recovery in the metal-treating outlet for phosphorus will take a long time.

The many other uses of phosphorus are diverse and generally small. The derivatives going into agricultural chemicals such as pesticides hold the brightest prospects. The others are in the small-growth category.

BEST AVAILABLE COPY

Congressional voting records on key chemical issues

Last year, 82% of the 9% of American Chemical Society members responding to a question included as part of the dues mailing expressed the desire that C&EN publish "the voting record of each U.S. Congressman on certain issues of concern to chemists." As requested by the ACS Board of Directors, C&EN in this issue publishes a summary of 13 House votes taken this year.

The votes were taken on amendments to and/or final passage of six different bills. A careful reading of both the explanation and a Congressman's vote is necessary. A yea vote is not necessarily pro-science just as a nay vote is not necessarily antiscience. In some cases a nay vote supports a higher level of research funding.

In any case, a vote against a particular bill should be interpreted with special care. For example, a no vote on the HUD-Independent Agencies Appropriation bill may mean that someone didn't like the level of housing subsidies included therein, but still supported the scientific research that also is funded under that bill.

A corresponding voting record for the Senate is not published here although it did pass five of the six bills acted on by the House. The Senate took these actions:

- *On July 9, 1981, it passed by a voice vote S. 255, which restores to the term of a patent the period of time needed to gain federal regulatory approval.*
- *On Dec. 8, 1981, by a unanimous vote of 90 yeas, it passed S. 881 requiring federal agencies with an R&D budget greater than $100 million to set aside specific percentages for small businesses.*
- *On April 29, 1982, it passed by a voice vote S. 2271 setting the fiscal 1983 authorization for the National Bureau of Standards at $111.5 million.*
- *On May 13, 1982, on a unanimous vote of 92 yeas, it adopted the amendment offered by Sen. Mark Hatfield (R.-Ore.) to S. 2248, the Department of Defense fiscal 1983 authorization bill. The amendment prohibits the obligation or expenditure of funds for binary chemical weapons unless the President were to make certain certifications.*
- *On Sept. 24, 1982, it passed by 73 yeas to 11 nays H.R. 6596, which appropriates funds for fiscal 1983 for the Department of Housing & Urban Development and certain independent agencies such as the National Science Foundation and the National Aeronautics & Space Administration. No amendment that concerned scientific research was offered.*

State, district Representative	Issues voted on (see key) 1	2	3	4	5	6	7	8	9	10	11	12	13
ALABAMA				VOICE VOTE									
1. **Edwards**	N	Y	Y		N	Y	Y	N	N	N	N	Y	Y
2. **Dickinson**	—	N	N		N	Y	—	N	N	N	N	Y	Y
3. Nichols	N	Y	Y		Y	N	Y	Y	N	N	N	Y	Y
4. Bevill	N	Y	Y		Y	N	Y	Y	N	N	Y	Y	N
5. Flippo	N	Y	Y		Y	N	Y	Y	N	N	Y	Y	Y
6. **Smith**	Y	N	N		—	Y	N	Y	N	N	Y	Y	F
7. Shelby	N	N	Y		Y	Y	Y	Y	N	N	N	Y	Y
ALASKA													
Young	Y	N	Y		N	Y	Y	Y	N	N	—	—	F
ARIZONA													
1. **Rhodes**	Y	N	Y		N	Y	Y	—	—	—	N	Y	Y
2. Udall	N	Y	Y		Y	N	Y	Y	Y	Y	Y	—	N
3. Stump	Y	N	N		N	Y	N	N	N	N	N	Y	Y

Key to voting issues

1. H.R. 5842—NSF fiscal 1983 authorization. Amendment by Winn (R.-Kan.) to reduce funding levels to President's request, cutting by $30 million funds for science and engineering education (adopted 194 to 191) 5/19/82.

2. H.R. 5842—NSF fiscal 1983 authorization. Amendment by Peyser (D.-N.Y.) to restore $20 million of the $30 million deleted from science and engineering education funds (adopted 203 to 188) 5/19/82.

3. H.R. 5842—NSF fiscal 1983 authorization. Final passage of the bill providing $1,052.3 million for research and related activities, $35 million for science and engineering education (passed 282 to 111) 5/19/82

4. H.R. 5272—NBS fiscal 1983 authorization. Amendment by Walker (R.-Pa.) to reduce funding levels to President's request, cutting $12.5 million (adopted by voice vote) 5/19/82.

5. H.R. 5272—NBS fiscal 1983 authorization. Amendment by Fuqua (D.-Fla.) to Walker amendment limiting the cut to $6.2 million (adopted 195 to 191) 5/19/82.

6. H.R. 5272—NBS fiscal 1983 authorization. Motion by Walker (R.-Pa.) to send bill back to committee with instructions to delete a further $6 million (rejected 193 to 193) 5/19/82.

7. H.R. 5272—NBS fiscal 1983 authorization. Final passage of the bill providing $118 million (passed 249 to 131) 5/19/82.

8. H.R. 4326—Small Business Innovation Act. Final passage of the bill requiring federal agencies with an R&D budget greater than $100 million to set aside specific percentages for small businesses (passed 353 to 57) 6/23/82.

9. H.R. 6030—DOD fiscal 1983 authorization. Amendment by Bethune (R.-Ark.) prohibiting use of authorized funds for procurement of binary munitions or for production facilities (adopted 232 to 181) 7/22/82.

10. H.R. 6030—DOD fiscal 1983 authorization. Amendment by Zablocki (D.-Wis.) deleting $54 million requested for production of binary chemical weapons (adopted 251 to 159) 7/22/82.

11. H.R. 6956—HUD-independent agencies fiscal 1983 appropriation. Amendment by Scheuer (D.-N.Y.) increasing funding for EPA R&D activities $25 million (rejected 131 to 263) 9/15/82.

12. H.R. 6956—HUD-independent agencies fiscal 1983 appropriation. Final passage of bill providing, out of total of $47 billion, $1.1 billion for NSF, $6.4 billion for NASA, and $3.7 billion for EPA (passed 343 to 38) 9/15/82.

13. H.R. 6444—Patent Term Restoration Act. Vote to suspend the rules and pass bill (two-thirds majority needed) restoring to the term of a patent the period of time needed to gain regulatory approval (failed 250 to 132) 9/15/82.

Key to symbols:

A = Against, but not voting
F = For, but not voting
N = Voted against (nay)
P = Voted present
Y = Voted for (yea)
– = Did not vote or make position known
Boldface names = Republicans
(Democrats' names in light type)

State, district	Issues voted on (see key)												
Representative	1	2	3	4	5	6	7	8	9	10	11	12	13
4. **Rudd**	Y	N	N		N	Y	N	N	N	N	N	Y	Y
ARKANSAS													
1. Alexander	N	Y	Y		Y	N	Y	Y	N	N	N	—	Y
2. **Bethune**	Y	N	N		N	Y	N	Y	Y	Y	N	—	—
3. **Hammerschmidt**	Y	N	N		N	Y	N	Y	N	N	N	Y	Y
4. Anthony	Y	Y	Y		Y	N	Y	Y	N	N	N	Y	Y
CALIFORNIA													
1. **Chappie**	Y	N	N		N	Y	N	Y	—	—	N	N	Y
2. **Clausen**	Y	N	Y		N	Y	N	Y	Y	Y	N	Y	Y
3. Matsui	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
4. Fazio	N	Y	Y		Y	N	Y	N	N	Y	N	Y	N
5. Burton, John	—	—	—	VOICE VOTE	—	—	—	Y	—	—	—	—	—
6. Burton, Philip	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
7. Miller	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
8. Dellums	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
9. Stark	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
10. Edwards	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
11. Lantos	N	Y	Y		Y	N	Y	N	Y	Y	N	Y	N
12. **McCloskey**	Y	N	Y		—	—	—	N	Y	Y	N	Y	Y
13. Mineta	N	Y	Y		Y	N	Y	N	Y	Y	Y	Y	N
14. **Shumway**	Y	N	N		N	N	N	N	N	N	N	N	Y
15. Coelho	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	Y
16. Panetta	N	Y	Y		Y	N	Y	—	Y	Y	N	Y	N
17. **Pashayan**	Y	N	N		N	Y	N	Y	N	N	N	Y	Y
18. **Thomas**	F	A	A		—	F	A	Y	N	N	—	—	F
19. **Lagomarsino**	Y	N	N		N	Y	N	Y	N	N	N	Y	N
20. **Goldwater**	—	—	—		—	—	—	Y	N	—	—	Y	—
21. **Fielder**	Y	N	Y		N	Y	Y	Y	N	N	N	Y	Y
22. **Moorhead**	Y	N	N		N	Y	N	Y	N	N	N	N	Y
23. Beilenson	N	Y	Y		Y	N	Y	N	Y	Y	Y	Y	N
24. Waxman	N	Y	Y		Y	N	Y	N	Y	Y	Y	Y	N
25. Roybal	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
26. **Rousselot**	Y	N	N		N	Y	N	Y	N	—	N	Y	Y
27. **Dornan**	Y	N	N		—	F	—	Y	N	N	N	Y	Y
28. Dixon	A	F	—		—	A	—	Y	Y	—	F	Y	N
29. Hawkins	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
30. Martinez[a]									Y	Y	Y	Y	N
31. Dymally	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	Y
32. Anderson	N	Y	Y		N	Y	Y	Y	Y	Y	N	Y	N
33. **Grisham**	—	—	—		—	—	—	Y	N	N	—	Y	Y
34. **Lungren**	Y	N	N		N	Y	N	Y	N	N	N	Y	Y
35. **Dreier**	F	A	—		—	—	—	Y	N	N	N	N	Y
36. Brown	N	Y	Y	VOICE VOTE	Y	N	Y	N	Y	Y	Y	Y	Y
37. **Lewis**	Y	N	N		N	Y	N	Y	N	N	Y	N	Y
38. Patterson	N	Y	Y		Y	N	Y	N	—	Y	N	Y	N
39. **Dannenmeyer**	Y	N	N		N	Y	N	N	N	N	N	N	Y
40. **Badham**	—	—	—		—	—	—	N	N	N	N	N	Y
41. **Lowery**	Y	N	Y		N	Y	N	Y	N	N	N	—	Y
42. **Hunter**	Y	N	N		N	Y	N	Y	N	N	N	Y	Y
43. **Burgener**	—	A	—		—	—	—	N	—	—	N	—	N
COLORADO													
1. Schroeder	N	Y	N		Y	N	Y	Y	Y	Y	Y	N	N
2. Wirth	—	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
3. Kogovsek	Y	Y	Y		Y	N	Y	Y	Y	Y	N	Y	N
4. **Brown**	Y	N	Y		N	Y	N	Y	Y	Y	N	N	Y
5. **Kramer**	Y	N	N		N	Y	N	Y	N	N	N	Y	Y
CONNECTICUT													
1. Kennelly	N	Y	Y		Y	N	Y	Y	Y	Y	N	Y	Y
2. Gejdenson	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	Y
3. **De Nardis**	N	Y	Y		N	Y	N	—	Y	Y	Y	Y	Y

State, district	Issues voted on (see key)												
Representative	1	2	3	4	5	6	7	8	9	10	11	12	13
4. **McKinney**	Y	N	Y		N	Y	Y	Y	Y	Y	Y	Y	Y
5. Ratchford	Y	Y	Y		Y	N	Y	Y	Y	Y	N	Y	Y
6. Moffett	N	Y	Y		Y	—	Y	Y	Y	Y	—	Y	—
DELAWARE													
Evans	Y	N	Y		N	Y	Y	Y	Y	Y	N	Y	Y
FLORIDA													
1. Hutto	N	Y	Y		Y	N	Y	Y	N	N	N	Y	Y
2. Fuqua	N	Y	Y		Y	N	—	N	N	N	Y	Y	Y
3. Bennett	Y	N	Y		N	Y	Y	Y	N	N	N	N	Y
4. Chappell	N	Y	Y		Y	N	Y	Y	N	N	—	—	—
5. **McCollum**	Y	N	N		N	Y	N	Y	N	N	N	Y	N
6. **Young**	Y	N	N		N	Y	Y	Y	N	N	N	Y	Y
7. Gibbons	N	Y	Y	VOICE VOTE	Y	N	Y	Y	N	N	Y	Y	Y
8. Ireland	N	N	Y		Y	N	Y	Y	N	N	N	Y	Y
9. Nelson	N	Y	Y		Y	N	Y	Y	N	N	Y	Y	N
10. **Bafalis**	—	—	—		—	—	—	—	N	N	—	—	—
11. Mica	N	Y	Y		Y	N	Y	Y	Y	Y	N	Y	N
12. **Shaw**	Y	N	N		N	Y	N	Y	N	N	N	Y	N
13. Lehman	N	Y	Y		Y	N	Y	Y	Y	Y	N	Y	Y
14. Pepper	N	Y	Y		Y	N	Y	Y	—	—	A	—	A
15. Fascell	N	Y	Y		Y	N	Y	Y	Y	Y	N	Y	N
GEORGIA													
1. Ginn	—	—	—		—	—	—	—	—	—	N	Y	Y
2. Hatcher	N	Y	Y		Y	N	Y	Y	N	—	N	Y	Y
3. Brinkley	N	Y	Y		Y	N	Y	Y	N	N	N	Y	Y
4. Levitas	Y	N	Y		Y	N	Y	Y	N	N	N	N	Y
5. Fowler	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	Y
6. **Gingrich**	N	Y	Y		N	Y	N	Y	N	N	Y	—	N
7. McDonald	Y	N	N		N	Y	N	N	N	N	N	N	Y
8. Evans	N	Y	N		Y	Y	N	Y	N	N	—	—	—
9. Jenkins	N	Y	Y		N	Y	N	Y	Y	Y	N	Y	Y
10. Barnard	N	Y	Y		Y	Y	N	Y	N	N	N	Y	Y
HAWAII													
1. Heftel	N	Y	Y		Y	N	Y	Y	N	P	N	Y	N
2. Akaka	N	Y	Y		Y	N	Y	Y	N	Y	—	—	A
IDAHO													
1. **Craig**	Y	N	N		N	Y	N	Y	Y	Y	N	Y	Y
2. **Hansen**	Y	N	N		N	Y	N	N	N	N	N	N	Y
ILLINOIS													
1. Washington	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
2. Savage	N	Y	Y	VOICE VOTE	Y	N	Y	Y	Y	Y	Y	Y	—
3. Russo	N	Y	Y		Y	N	Y	Y	Y	Y	Y	N	N
4. **Derwinski**	Y	N	N		N	Y	N	Y	N	N	N	—	Y
5. Fary	N	Y	Y		Y	N	Y	Y	N	Y	Y	Y	N
6. **Hyde**	Y	N	N		N	Y	N	Y	N	N	N	Y	Y
7. Collins	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
8. Rostenkowski	N	Y	Y		Y	N	Y	Y	Y	Y	N	Y	N
9. Yates	N	Y	Y		Y	N	Y	N	Y	Y	Y	Y	N
10. **Porter**	Y	N	Y		N	Y	N	Y	Y	Y	N	Y	Y
11. Annunzio	N	Y	Y		Y	N	Y	Y	N	Y	N	Y	N
12. **Crane, Philip**	F	A	A		—	F	A	N	N	N	N	N	Y
13. **McClory**	Y	N	Y		N	Y	Y	Y	Y	Y	—	—	F
14. **Erlenborn**	Y	N	Y		N	Y	N	N	N	Y	N	Y	Y
15. **Corcoran**	Y	N	N		N	Y	N	Y	N	N	N	Y	Y
16. **Martin**	Y	N	N		N	Y	N	Y	Y	Y	N	Y	Y
17. **O'Brien**	Y	N	N		N	Y	N	Y	N	N	N	Y	Y
18. **Michel**	F	N	N		N	Y	N	Y	N	N	N	Y	Y
19. **Railsback**	Y	N	Y		N	Y	Y	Y	Y	Y	N	Y	Y
20. **Findley**	Y	N	Y		—	F	N	Y	Y	Y	N	Y	N

State, district Representative	1	2	3	4	5	6	7	8	9	10	11	12	13
21. **Madigan**	Y	N	N	VOICE VOTE	N	Y	N	Y	N	Y	N	Y	Y
22. **Crane, Daniel**	Y	N	N		N	Y	N	N	N	N	N	N	F
23. Price	N	Y	Y		Y	N	Y	Y	N	N	N	Y	Y
24. Simon	N	Y	Y		Y	N	Y	Y	Y	Y	Y	—	N
INDIANA													
1. Vacant													
2. Fithian	N	N	Y		Y	N	Y	—	Y	Y	—	—	—
3. **Hiler**	Y	N	N		N	Y	N	Y	N	N	N	Y	Y
4. **Coats**	Y	N	N		N	Y	N	Y	Y	Y	N	Y	Y
5. **Hillis**	Y	N	Y		N	Y	N	Y	N	N	N	Y	—
6. Evans	N	Y	Y		Y	N	Y	Y	Y	Y	N	Y	—
7. **Myers**	Y	N	Y		N	Y	N	Y	N	N	N	Y	Y
8. **Deckard**	Y	—	Y		N	Y	N	Y	Y	Y	Y	Y	Y
9. Hamilton	N	Y	Y		Y	N	Y	Y	Y	Y	N	Y	Y
10. Sharp	N	Y	Y		N	N	Y	Y	Y	Y	Y	Y	Y
11. Jacobs	—	—	—		—	—	—	N	Y	Y	N	Y	N
IOWA													
1. **Leach**	N	Y	F		N	Y	Y	Y	Y	Y	Y	Y	N
2. **Tauke**	—	Y	Y		N	Y	N	Y	Y	Y	Y	—	Y
3. **Evans**	N	Y	Y		N	Y	N	Y	Y	Y	Y	Y	N
4. Smith	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
5. Harkin	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
6. Bedell	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
KANSAS													
1. **Roberts**	Y	N	N		N	Y	N	Y	Y	Y	N	Y	Y
2. **Jeffries**	Y	N	N		N	Y	N	Y	N	N	N	N	Y
3. **Winn**	Y	N	Y		N	Y	N	Y	N	N	N	Y	Y
4. Glickman	N	Y	Y		Y	N	Y	Y	Y	Y	N	Y	N
5. **Whittaker**	Y	N	N		N	Y	N	Y	Y	Y	N	Y	Y
KENTUCKY													
1. Hubbard	—	—	—		—	—	—	N	N	N	N	N	Y
2. Natcher	Y	N	Y		N	N	Y	Y	Y	Y	N	Y	Y
3. Mazzoli	N	Y	Y		Y	N	Y	Y	Y	Y	N	Y	Y
4. **Snyder**	Y	N	N		N	Y	N	Y	N	N	N	Y	N
5. **Rogers**	Y	—	—		—	—	—	Y	N	N	N	Y	Y
6. **Hopkins**	Y	N	N		N	Y	N	N	Y	Y	N	Y	N
7. Perkins	N	Y	Y		N	N	Y	Y	Y	Y	Y	Y	Y
LOUISIANA													
1. **Livingston**	Y	N	N		N	Y	Y	Y	N	N	N	Y	Y
2. Boggs	N	Y	Y		Y	N	Y	Y	Y	Y	N	Y	N
3. Tauzin	Y	N	Y		N	Y	Y	Y	N	N	N	Y	Y
4. Roaemer	Y	N	Y		N	Y	Y	Y	N	N	N	N	N
5. Huckaby	Y	N	Y		N	N	Y	Y	—	N	N	Y	N
6. **Moore**	Y	N	Y		N	Y	Y	N	N	N	N	Y	Y
7. Breaux	Y	Y	Y		Y	N	Y	Y	N	—	N	Y	Y
8. Long	N	Y	Y		Y	N	Y	Y	Y	Y	N	Y	N
MAINE													
1. **Emery**	Y	N	Y		N	Y	Y	Y	Y	Y	Y	Y	Y
2. **Snowe**	Y	N	Y		N	Y	Y	Y	Y	Y	N	Y	N
MARYLAND													
1. Dyson	Y	N	Y		Y	N	Y	—	N	N	Y	Y	N
2. Long	N	—	Y		Y	N	Y	Y	Y	Y	Y	Y	N
3. Mikulski	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
4. **Holt**	Y	N	Y		N	Y	Y	Y	N	N	Y	—	Y
5. Hoyer	N	—	Y		Y	N	Y	Y	Y	Y	Y	Y	N
6. Byron	Y	N	Y		Y	N	Y	Y	N	N	N	Y	—
7. Mitchell	N	Y	Y		Y	N	Y	Y	Y	Y	—	Y	N
8. Barnes	N	Y	Y		Y	N	Y	Y	—	—	Y	Y	N
MASSACHUSETTS													
1. **Conte**	N	Y	Y	VOICE VOTE	N	Y	Y	Y	Y	Y	N	Y	Y
2. Boland	N	Y	Y		Y	N	Y	—	Y	Y	N	Y	Y
3. Early	N	Y	Y		Y	N	Y	N	Y	Y	N	Y	N
4. Frank	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
5. Shannon	N	Y	Y		Y	N	Y	N	Y	Y	N	Y	N
6. Mavroules	N	Y	Y		Y	N	Y	Y	Y	Y	N	Y	N
7. Markey	N	Y	Y		Y	N	Y	Y	Y	Y	N	Y	N
8. O'Neill													
9. Moakley	N	Y	Y		Y	N	Y	Y	Y	—	Y	Y	N
10. **Heckler**	N	Y	Y		N	Y	Y	Y	Y	Y	Y	Y	N
11. Donnelly	N	Y	Y		Y	N	Y	Y	Y	Y	N	Y	N
12. Studds	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
MICHIGAN													
1. Conyers	N	Y	Y		Y	N	Y	N	Y	Y	Y	Y	N
2. **Pursell**	N	N	Y		N	Y	Y	Y	Y	Y	N	Y	Y
3. Wolpe	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	Y
4. **Siljander**	Y	N	N		N	Y	N	—	N	N	N	Y	Y
5. **Sawyer**	Y	N	Y		N	Y	Y	Y	N	N	N	Y	Y
6. Dunn	N	Y	Y		N	Y	N	Y	Y	Y	N	Y	Y
7. Kildee	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
8. Traxler	N	Y	Y		Y	N	Y	Y	Y	Y	N	Y	N
9. **Vander Jagt**	Y	N	Y		N	Y	Y	Y	Y	Y	N	Y	Y
10. Albosta	Y	Y	Y		Y	N	Y	Y	Y	Y	N	Y	Y
11. **Davis**	Y	N	Y		N	Y	Y	Y	N	N	N	Y	Y
12. Bonior	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
13. Crockett	N	Y	Y		—	—	—	Y	Y	Y	Y	Y	N
14. Hertel	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
15. Ford	N	Y	Y		Y	N	Y	Y	Y	—	Y	Y	N
16. Dingell	N	Y	Y		Y	N	Y	N	N	N	Y	Y	Y
17. Brodhead	N	N	Y		Y	N	Y	Y	Y	Y	Y	Y	N
18. Blanchard	N	Y	Y		Y	N	Y	—	Y	Y	—	—	—
19. **Broomfield**	Y	N	Y		N	Y	N	Y	Y	Y	N	Y	Y
MINNESOTA													
1. **Erdahl**	—	—	—		—	—	—	Y	Y	Y	N	Y	N
2. **Hagedorn**	Y	N	N		N	Y	N	Y	N	N	N	Y	Y
3. **Frenzel**	Y	N	N		N	Y	N	Y	Y	Y	N	Y	Y
4. Vento	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
5. Sabo	N	Y	Y		Y	N	Y	N	Y	Y	N	Y	N
6. Weber	Y	N	N		N	Y	N	Y	Y	Y	Y	Y	Y
7. **Stangeland**	Y	N	N		N	Y	N	Y	N	N	N	Y	—
8. Oberstar	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
MISSISSIPPI													
1. Whitten	Y	N	Y		N	Y	Y	Y	Y	Y	N	Y	Y
2. Bowen	—	—	—		—	—	—	Y	—	—	N	Y	Y
3. Montgomery	Y	N	Y		N	Y	Y	—	N	N	N	Y	Y
4. Dowdy	Y	Y	Y		Y	N	Y	Y	—	N	N	Y	N
5. **Lott**	Y	N	N		N	Y	N	Y	N	N	N	Y	Y
MISSOURI													
1. Clay	N	Y	Y		Y	N	Y	—	—	—	Y	Y	N
2. Young	N	Y	Y		Y	N	Y	Y	N	N	N	Y	Y
3. Gephardt	N	Y	Y		Y	N	Y	N	N	N	N	Y	Y
4. Skelton	N	Y	N		N	Y	N	Y	N	N	N	Y	—
5. Bolling	N	Y	—		Y	—	—	—	N	N	—	—	N
6. **Coleman**	N	Y	Y		N	Y	N	Y	—	—	N	Y	Y
7. **Taylor**	Y	N	N		N	Y	N	N	N	N	N	Y	Y
8. **Bailey**	Y	N	Y		N	Y	N	Y	Y	Y	N	Y	N
9. Volkmer	N	Y	Y		Y	N	Y	Y	N	Y	Y	Y	Y
10. **Emerson**	Y	N	N		N	Y	N	Y	—	—	N	Y	Y

State, district Representative	Issues voted on (see key)												
	1	2	3	4	5	6	7	8	9	10	11	12	13
MONTANA													
1. Williams	N	Y	Y	VOICE VOTE	Y	N	Y	Y	Y	Y	N	Y	N
2. **Marlenee**	—	N	N		N	Y	N	Y	N	Y	N	N	Y
NEBRASKA													
1. **Bereuter**	Y	N	Y		N	Y	N	Y	Y	Y	N	Y	N
2. **Daub**	Y	N	Y		N	Y	N	Y	Y	Y	N	Y	Y
3. **Smith**	Y	N	N		N	Y	N	Y	Y	Y	N	Y	Y
NEVADA													
Santini	Y	N	Y		Y	Y	Y	Y	—	—	—	—	—
NEW HAMPSHIRE													
1. D'Amours	N	Y	Y		N	Y	Y	Y	Y	Y	—	Y	—
2. **Gregg**	Y	N	N		N	Y	N	Y	Y	Y	N	Y	Y
NEW JERSEY													
1. Florio	Y	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	Y
2. Hughes	Y	N	Y		Y	N	Y	Y	Y	Y	Y	Y	Y
3. Howard	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
4. **Smith**	Y	N	Y		N	Y	Y	Y	Y	Y	Y	Y	Y
5. **Fenwick**	Y	N	Y		—	—	F	Y	Y	Y	Y	Y	Y
6. **Forsythe**	Y	N	Y		N	Y	N	Y	Y	Y	—	—	F
7. **Roukema**	Y	N	Y		N	Y	Y	Y	Y	Y	N	Y	Y
8. Roe	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	Y
9. **Hollenbeck**	N	Y	Y		N	N	Y	Y	Y	Y	Y	Y	Y
10. Rodino	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	Y
11. Minish	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	Y
12. **Rinaldo**	N	Y	Y		N	Y	Y	Y	Y	Y	Y	Y	Y
13. **Courter**	—	—	F		—	—	F	Y	N	N	Y	Y	F
14. Guarini	Y	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	Y
15. Dwyer	Y	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	Y
NEW MEXICO													
1. **Lujan**	Y	N	N		N	Y	N	Y	N	N	N	Y	Y
2. **Skeen**	Y	N	Y		N	Y	N	Y	N	N	N	Y	Y
NEW YORK													
1. **Carney**	Y	N	Y		N	Y	N	Y	N	N	N	Y	—
2. Downey	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
3. **Carman**	Y	N	N		N	Y	N	Y	N	N	N	Y	Y
4. **Lent**	—	N	N		N	Y	N	Y	N	N	Y	Y	Y
5. **McGrath**	Y	N	Y		N	Y	N	Y	Y	Y	Y	—	Y
6. **Leboutillier**	Y	N	N		N	Y	N	Y	N	N	N	Y	Y
7. Addabbo	Y	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
8. Rosenthal	N	Y	Y		Y	N	Y	Y	Y	Y	Y	—	N
9. Ferraro	N	Y	Y		—	—	—	Y	Y	Y	Y	Y	N
10. Biaggi	N	Y	Y		Y	N	Y	Y	Y	Y	N	Y	Y
11. Scheuer	N	Y	Y		Y	N	Y	N	Y	Y	Y	Y	Y
12. Chisholm	N	Y	Y		—	N	Y	Y	—	Y	Y	Y	N
13. Solarz	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
14. Vacant													
15. Zeferetti	—	F	F		—	A	F	Y	Y	Y	F	—	—
16. Schumer	N	Y	Y		Y	N	Y	—	Y	Y	N	Y	N
17. **Molinari**	Y	N	Y		N	Y	N	Y	Y	Y	Y	Y	N
18. **Green**	N	Y	Y		N	Y	Y	Y	Y	Y	N	Y	Y
19. Rangel	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
20. Weiss	N	Y	Y		Y	N	Y	—	Y	Y	—	—	—
21. Garcia	N	Y	Y		Y	N	Y	—	Y	Y	N	Y	Y
22. Bingham	N	Y	Y		Y	N	Y	Y	Y	Y	N	Y	Y
23. Peyser	N	Y	Y		—	N	Y	Y	Y	Y	Y	Y	N
24. Ottinger	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
25. **Fish**	—	—	—		—	Y	Y	Y	Y	Y	N	Y	Y
26. **Gilman**	Y	N	Y		N	Y	Y	Y	N	Y	—	—	Y
27. McHugh	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	Y
28. Stratton	Y	Y	Y		Y	Y	Y	N	N	N	N	Y	Y
29. **Solomon**	Y	N	N	VOICE VOTE	N	Y	N	Y	—	—	Y	N	Y
30. **Martin**	Y	N	Y		N	Y	Y	Y	N	N	Y	Y	Y
31. **Mitchell**	Y	N	Y		N	Y	Y	Y	N	N	N	Y	Y
32. **Wortley**	Y	N	N		N	Y	N	Y	Y	Y	N	—	Y
33. **Lee**	Y	N	Y		N	Y	Y	Y	Y	Y	—	—	—
34. **Horton**	—	N	Y		N	Y	Y	Y	Y	Y	N	Y	Y
35. **Conable**	Y	N	N		N	Y	N	Y	Y	N	N	Y	N
36. La Falce	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
37. Nowak	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
38. **Kemp**	—	N	N		N	Y	N	Y	N	N	N	Y	Y
39. Lundine	—	—	—		—	—	—	Y	Y	Y	N	Y	Y
NORTH CAROLINA													
1. Jones	N	N	Y		Y	N	Y	Y	N	Y	N	Y	Y
2. Fountain	Y	N	Y		N	Y	Y	N	N	N	—	—	—
3. Whitley	Y	N	Y		N	Y	Y	Y	N	N	N	—	Y
4. Andrews	N	Y	Y		Y	N	Y	N	Y	Y	Y	Y	Y
5. Neal	N	Y	Y		Y	N	Y	Y	N	Y	N	Y	Y
6. **Johnston**	Y	N	N		N	Y	N	Y	N	N	N	N	Y
7. Rose	N	N	Y		Y	N	Y	Y	Y	Y	N	Y	Y
8. Hefner	Y	N	Y		Y	Y	Y	Y	N	Y	N	Y	Y
9. **Martin**	—	—	—		—	—	—	N	Y	Y	N	Y	Y
10. **Broyhill**	Y	N	N		N	Y	N	Y	Y	Y	N	Y	Y
11. **Hendon**	Y	N	N		N	Y	N	Y	N	N	N	Y	Y
NORTH DAKOTA													
Dorgan	N	Y	Y		Y	N	Y	Y	Y	Y	N	Y	N
OHIO													
1. **Gradison**	Y	N	N		N	Y	N	N	N	Y	N	Y	N
2. Luken	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	Y
3. Hall	Y	N	Y		Y	N	N	Y	Y	Y	Y	Y	N
4. **Oxley**	Y	N	N		N	Y	N	Y	N	Y	N	Y	Y
5. **Latta**	Y	N	N		N	Y	N	Y	N	N	N	N	Y
6. **McEwen**	Y	N	N		N	Y	N	Y	Y	Y	N	Y	Y
7. **Brown**	—	—	—		—	—	—	—	—	—	—	—	—
8. **Kindness**	Y	N	N		N	Y	N	Y	N	N	N	N	Y
9. **Weber**	Y	Y	Y		N	Y	Y	Y	Y	Y	N	Y	Y
10. **Miller**	Y	N	N		N	Y	N	Y	N	N	N	Y	Y
11. **Stanton**	—	—	—		—	—	N	Y	Y	Y	N	—	—
12. Shamansky	N	Y	Y		Y	N	Y	Y	Y	Y	N	Y	Y
13. Pease	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
14. Seiberling	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
15. **Wylie**	Y	N	Y		N	—	—	Y	Y	Y	N	Y	Y
16. **Regula**	Y	N	Y		N	Y	N	Y	Y	Y	N	Y	Y
17. **Ashbrook**[b]	—	—	—		—	—	—	—	N	N	N	N	Y
18. **Applegate**	Y	N	N		Y	Y	N	Y	N	Y	N	Y	N
19. **Williams**	N	N	N		N	Y	Y	Y	Y	Y	N	Y	—
20. Oakar	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
21. Stokes	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
22. Eckart	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
23. Mottl	N	Y	Y		Y	N	Y	Y	N	N	Y	Y	N
OKLAHOMA													
1. Jones	N	Y	Y		Y	N	Y	Y	Y	Y	N	Y	Y
2. Synar	N	Y	Y		Y	N	Y	Y	Y	Y	N	Y	Y
3. Watkins	N	N	N		Y	N	Y	Y	N	N	N	Y	Y
4. McCurdy	N	Y	Y		Y	N	Y	Y	Y	Y	N	Y	Y
5. **Edwards**	Y	N	N		N	—	—	Y	Y	Y	N	N	Y
6. English	Y	N	N		Y	N	Y	Y	N	N	N	N	Y
OREGON													
1. AuCoin	—	—	—		—	—	—	Y	Y	Y	N	Y	Y
2. **Smith**	Y	N	N		N	Y	N	Y	N	N	N	N	Y
3. Wyden	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N

State, district	Issues voted on (see key)												
Representative	1	2	3	4	5	6	7	8	9	10	11	12	13
4. Weaver	—	—	—		—	—	—	Y	Y	Y	—	Y	N
PENNSYLVANIA													
1. Foglietta	—	—	—		—	—	—	Y	Y	Y	Y	Y	N
2. Gray	A	F	—		—	A	—	Y	Y	Y	Y	—	—
3. Smith	—	—	—		—	—	—	Y	Y	Y	N	—	N
4. **Dougherty**	—	—	—		—	—	—	N	N	N	N	Y	—
5. **Schulze**	Y	N	N		N	Y	N	Y	N	N	N	—	Y
6. Yatron	N	Y	Y		Y	N	Y	Y	Y	Y	N	Y	Y
7. Edgar	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	Y
8. **Coyne, James**	Y	N	Y		N	Y	Y	Y	Y	Y	N	Y	Y
9. **Shuster**	Y	N	N		N	Y	N	Y	Y	Y	N	Y	Y
10. **McDade**	Y	N	Y		N	Y	Y	Y	Y	Y	N	Y	Y
11. **Nelligan**	Y	N	Y	VOICE VOTE	N	Y	Y	Y	N	N	N	Y	Y
12. Murtha	—	—	—		—	—	—	Y	N	N	N	Y	Y
13. **Coughlin**	Y	N	Y		N	Y	Y	—	Y	Y	N	Y	Y
14. Coyne, William	N	Y	Y		Y	N	Y	N	Y	Y	N	Y	N
15. **Ritter**	Y	N	N		N	N	Y	Y	N	N	N	Y	F
16. **Walker**	Y	N	N		N	Y	N	Y	Y	Y	N	N	Y
17. Ertel	N	Y	Y		Y	N	Y	—	Y	Y	—	—	—
18. Walgren	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	Y
19. **Goodling**	Y	N	Y		N	Y	N	Y	Y	Y	N	Y	Y
20. Gaydos	—	—	—		—	—	—	Y	N	Y	N	Y	N
21. Bailey	N	Y	Y		Y	N	Y	Y	N	N	N	Y	Y
22. Murphy	N	Y	Y		Y	N	Y	Y	N	Y	N	Y	Y
23. **Clinger**	N	Y	Y		N	Y	N	Y	N	N	N	Y	Y
24. Marks	—	—	—		—	—	—	Y	—	—	—	—	Y
25. **Atkinson**	—	—	—		—	—	—	Y	N	N	N	Y	Y
RHODE ISLAND													
1. St. Germain	N	Y	Y		Y	N	Y	Y	Y	Y	N	Y	N
2. **Schneider**	Y	Y	Y		N	N	Y	Y	Y	Y	Y	Y	Y
SOUTH CAROLINA													
1. **Hartnett**	Y	N	N		N	Y	N	Y	N	N	N	Y	—
2. **Spence**	Y	N	N		N	Y	—	Y	N	N	N	Y	Y
3. Derrick	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	Y
4. **Campbell**	Y	N	N		N	Y	—	Y	N	N	N	Y	Y
5. Holland	N	Y	Y		Y	Y	—	—	N	N	N	Y	Y
6. **Napier**	Y	N	N		N	Y	—	Y	N	N	N	Y	Y
SOUTH DAKOTA													
1. Daschle	N	N	Y		Y	N	Y	N	Y	Y	N	Y	N
2. **Roberts**	Y	N	N		N	Y	N	Y	Y	Y	N	—	—
TENNESSEE													
1. **Quillen**	Y	N	N	VOICE VOTE	N	Y	N	N	N	N	N	Y	Y
2. **Duncan**	Y	Y	Y		N	Y	N	Y	N	N	N	Y	Y
3. Bouquard	N	Y	Y		Y	N	Y	N	N	N	Y	Y	F
4. Gore	N	Y	Y		Y	N	Y	Y	N	Y	Y	Y	N
5. Boner	Y	Y	Y		Y	N	Y	Y	N	N	N	—	Y
6. **Beard**	Y	N	N		N	Y	N	Y	N	N	N	Y	Y
7. Jones	Y	N	N		Y	Y	N	Y	—	—	N	Y	Y
8. Ford	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	Y
TEXAS													
1. Hall, Sam	Y	N	N		Y	N	Y	Y	Y	Y	N	Y	Y
2. Wilson	N	Y	Y		Y	N	Y	—	—	N	N	Y	Y
3. **Collins**	Y	N	N		N	Y	N	Y	N	N	N	N	—
4. Hall, Ralph	N	Y	Y		Y	N	Y	Y	N	N	N	Y	Y
5. Mattox	—	—	—		—	—	—	Y	Y	Y	—	—	—
6. Gramm	Y	N	N		Y	Y	N	N	N	N	N	N	Y
7. **Archer**	—	N	N		N	Y	N	Y	N	N	N	N	Y
8. Fields	Y	N	N		N	Y	N	Y	N	N	N	N	Y
9. Brooks	N	Y	Y		Y	N	Y	N	N	N	—	—	—
10. Pickle	Y	Y	Y		Y	N	Y	Y	N	Y	—	—	—
11. Leath	Y	N	N		Y	N	Y	Y	N	N	—	Y	Y
12. Wright	N	Y	Y		Y	N	Y	Y	N	Y	N	Y	Y
13. Hightower	Y	N	Y		N	Y	Y	Y	Y	Y	N	Y	Y
14. Patman	Y	N	Y		N	Y	Y	Y	N	N	N	Y	Y
15. de la Garza	Y	Y	Y		N	Y	Y	Y	N	N	N	Y	Y
16. White	N	Y	Y		Y	Y	Y	Y	N	N	N	Y	Y
17. Stenholm	Y	N	N		N	Y	N	Y	N	N	N	N	Y
18. Leland	A	F	—		—	A	—	Y	Y	Y	Y	Y	N
19. Hance	Y	Y	Y		N	N	N	Y	N	N	N	—	N
20. Gonzalez	N	Y	Y		Y	N	Y	Y	Y	Y	N	Y	N
21. **Loeffler**	Y	N	N		N	Y	N	Y	N	N	N	N	Y
22. **Paul**	Y	N	N	VOICE VOTE	N	Y	N	N	Y	Y	N	N	Y
23. Kazen	Y	N	Y		N	Y	Y	Y	N	N	N	Y	Y
24. Frost	N	—	Y		Y	N	Y	Y	Y	Y	Y	Y	Y
UTAH													
1. **Hansen**	—	—	A		—	—	A	Y	N	N	N	Y	Y
2. **Marriot**	Y	N	N		N	Y	N	Y	N	N	N	Y	Y
VERMONT **Jeffords**	N	Y	Y		N	Y	Y	Y	Y	Y	Y	Y	—
VIRGINIA													
1. **Trible**	—	—	—		—	—	—	Y	N	N	N	—	Y
2. **Whitehurst**	Y	N	N		N	Y	N	N	N	N	N	Y	Y
3. **Bliley**	Y	N	N		N	Y	N	N	N	N	N	Y	Y
4. **Daniel, Robert**	Y	N	N		N	Y	N	Y	N	N	N	Y	Y
5. Daniel, Dan	Y	N	N		N	Y	N	N	N	N	—	Y	Y
6. **Butler**	Y	N	N		N	Y	—	N	N	N	—	—	F
7. **Robinson**	Y	N	N		N	Y	N	N	N	N	N	Y	Y
8. **Parris**	Y	N	Y		N	Y	Y	Y	Y	Y	N	Y	Y
9. **Wampler**	Y	N	N		N	Y	N	N	N	N	N	Y	Y
10. **Wolf**	Y	N	Y		N	Y	Y	Y	N	N	N	Y	Y
WASHINGTON													
1. **Pritchard**	Y	N	Y		N	Y	—	Y	Y	Y	—	—	—
2. **Swift**	N	Y	Y		Y	N	Y	Y	Y	Y	N	Y	Y
3. Bonker	N	Y	Y		Y	N	Y	Y	Y	Y	N	Y	N
4. **Morrison**	Y	N	Y		N	Y	N	Y	N	N	N	Y	Y
5. Foley	N	Y	Y		Y	N	Y	Y	Y	Y	N	Y	Y
6. Dicks	Y	Y	Y		Y	N	Y	Y	N	Y	N	Y	N
7. Lowry	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	N
WEST VIRGINIA													
1. Mollohan	N	Y	Y	VOICE VOTE	Y	N	Y	—	N	N	N	Y	N
2. **Benedict**	Y	Y	Y		N	Y	N	Y	Y	Y	N	—	N
3. **Staton**	Y	N	N		N	Y	N	Y	N	N	N	Y	Y
4. Rahall	N	Y	Y		Y	N	Y	Y	Y	Y	N	Y	N
WISCONSIN													
1. Aspin	N	Y	Y		Y	N	Y	N	Y	Y	Y	Y	Y
2. Kastenmeier	N	Y	Y		Y	N	Y	Y	Y	Y	Y	Y	Y
3. **Gunderson**	Y	N	N		N	Y	N	Y	Y	Y	Y	Y	Y
4. Zablocki	N	Y	Y		N	N	Y	Y	Y	Y	N	Y	—
5. Reuss	N	Y	Y		Y	N	Y	Y	Y	Y	A	—	A
6. **Petri**	Y	N	Y		N	Y	N	Y	N	N	Y	Y	Y
7. Obey	N	Y	Y		Y	N	Y	N	Y	Y	Y	Y	N
8. Roth	Y	N	N		N	Y	N	Y	Y	Y	N	Y	Y
9. Sensenbrenner	Y	N	N		N	Y	N	N	Y	Y	Y	N	Y
WYOMING **Cheney**	Y	N	N		N	Y	N	N	N	N	N	N	Y

a Sworn in July 15. b Sworn in July 12.